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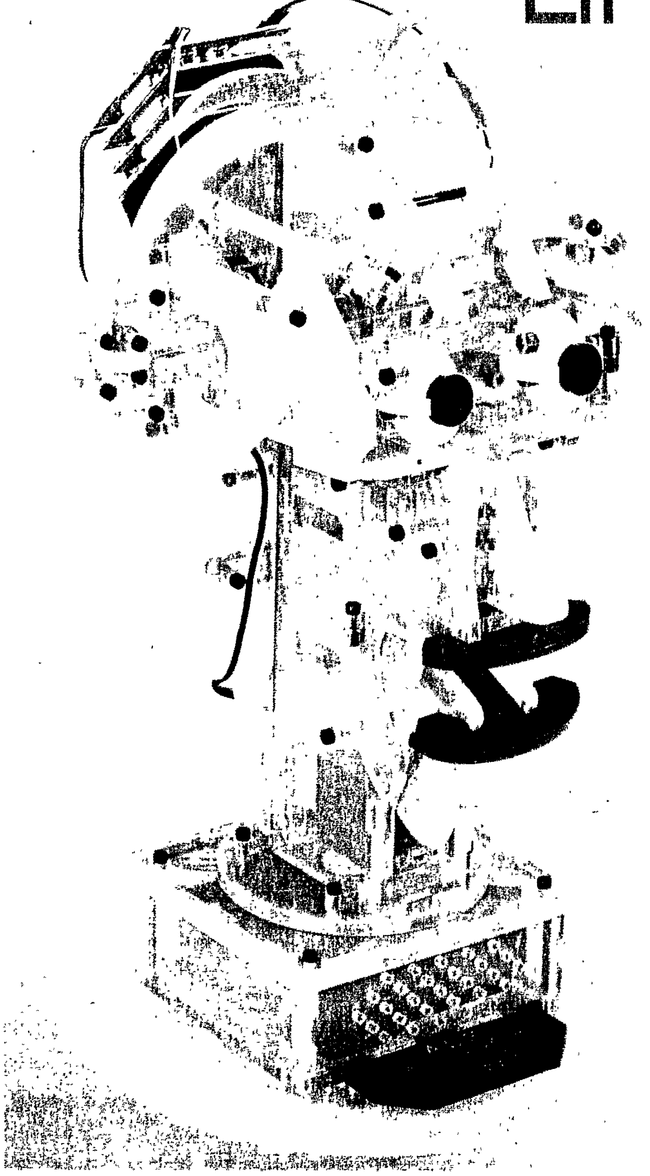

At the Massachus round-the-clock o

Cambridge, Mass

Pretend you know how to do this: Take a digital camera and wire it to a global positioning satellite receiver, and, for good measure, stick on a digital compass.

Could such a contraption—if you could make it—help kids learn?

Well, Brian Smith thinks so.

The faculty researcher at the Massachusetts Institute of Technology's Media Lab plans to give a bunch of the devices, as yet tested only with undergraduates, to an 8th grade social studies class. The students will walk between MIT's campus here and nearby Harvard Square, snapping away at views that interest them. The students will compare their digital photos—which Smith's gadgets have tagged with the precise location and the compass orientation of the camera when the picture was taken—to photos of the same route taken throughout the 20th century. The matching process uses a high-end software program called a geographic information system and an archive of more than 1,000 historical images donated by the Cambridge Historical Commission.

The next step is key: Students and teachers discuss how, and why, this urban landscape has changed over the past century, and whether the changes have been for better or worse.

Smith's multi-tasking camera is just one of the many gadgets developed by the Media Lab, a place where ideas about how to link new technologies to

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GNMENT

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etts Institute of Technology's Media Lab, ideas are percolating bout how to connect technology to student learning.

education are percolating round-the-clock. Housed in a five-story modernist box near the center of the MIT campus, the Media Lab can point to many successes in its now-16-year-old mission to explore the possibilities—in education and in other areas of life—of the digital age.

"They're on the cutting edge, and as with any kind of high-end institution, they have the luxury of doing very innovative and creative things," says Tracy Gray, the vice president of youth services at the Morino Institute, a Washington-based philanthropy that recently published a guide to using technology in after-school programs. "Really, their challenge is taking their learning approaches and getting them in the hands of those who could use them."

Smith's goal of putting novel technologies into the hands of young people—and have them pursue realistic experiences with academic payoffs—is shared by all the education researchers at the lab. The researchers are steeped in the philosophy that children learn by doing, and especially by designing and building things themselves. It's the familiar idea of project-based learning, yet the Media Lab applies such thinking to the new vistas that advances in computing are making possible.

To the casually dressed, intense, and sometimes scruffy faculty and graduate students who inhabit the lab at all hours, computing has the same role as clay to a guild of potters. Some of the "computational environments," as they call them, are familiar personal computers and handheld devices, along with standard

Lab researcher Bakhtiar Mikhak, left, watches as Brian Lion, an undergraduate at MIT, shows off "ALF." Lion designed ALF to encourage K-12 students to be more interested in computers, robotics, and science. ALF's big yellow head, shown on the opposite page at left, is programmed to make facial expressions that coincide with the recordings of people's voices.

By Andrew Trotter

Photographs by
James W. Prichard

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software and Web sites. But others seem far out. computers that are built into robots, name tags, clothing, stacking blocks, and musical instruments—and, of course, Smith's camera-plus-GPS system

And why would you want a programmable brick in the form of a name tag or stacking blocks?

In the case of the name tags, the researchers say those devices can detect other name tags worn by people in a school or at a conference, and display or transfer information

A computing device in the form of stacking blocks, meanwhile, could enable children who can't yet read to learn how to program a computer The youngsters would select blocks and place them in an order that would provide instructions to the computer, according to the researchers.

David Cavallo, who leads the lab's Future of Computing group, explains that robotics and other forms of computing "off the screen" give children a different and concrete learning experience that complements their use of desktop computers.

"By being a physical material off the screen," he says, a robot "lets you do different types of explorations that are still computational but have a different feel from when they happen on the screen."

In studying a physics concept such as force, for example, "there's something really nice when it's something you make, you can touch it," Cavallo adds.

Students can also delve deeper into autonomous control of machines and real engineering, rather than simply maneuver through simulated computer environments on screen. That helps the students see that they can program in the same computer language to operate real objects as they use to manipulate graphics on a screen

For instance, in a Media Lab-supported project on transportation at a school in Sao Paulo, Brazil, students have built a working model of traffic congestion with vehicles made of interlocking plastic Lego bricks and motors, sensors, and other Lego parts controlled by computers "It gives you a concrete way of thinking about these forces," Cavallo says

The lab's mission is also to look ahead five to 10 years, when now-embryonic technologies will be commercially available, and consider how they could be used in the arts, in education, and in other facets of life, says lab researcher Bakhtiar Mikhak

Indeed, predicting the commercial potential of new devices, the researchers insist, is important because that determines what will be available on a mass scale at an affordable price

At the same, the Media Lab itself helps influence which technologies ultimately will become widely available When researchers and their graduate and undergraduate students aren't tending to academic business, tinkering at their workbenches, or brainstorming among themselves, they are often demonstrating their new devices and sharing ideas with crisply attired visitors from nearly 160 corporations Those businesses include some of the world's largest technology companies, which pay annual fees of $100,000 and up for access to the lab researchers' ideas and inventions

As an old Media Lab slogan—"demo or die"—suggests, such contacts help keep the lights on Corporate sponsorships brought in $36 million in the 2000-01 academic year

The companies benefit, too. Lego Inc. was able to take the Media Lab's "programmable brick," a computer built into a small plastic block, and turn it into the RCX computer, the heart of Lego's popular robotics kits Like the original brick, the RCX has a liquid-crystal display screen, a memory chip, some control buttons, and six ports for taking in data from light or motion sensors and sending out instructions to motors and other attachments. The top and bottom surfaces also have the familiar Lego studs and tubes, which allow the RCX to be incorporated into mobile Lego models

Powered by batteries, the RCX runs programs written in versions of the computer language Logo, which is another area of research at the lab The RCX can store programs in its memory or execute instructions received via an infrared transmission from a personal computer.

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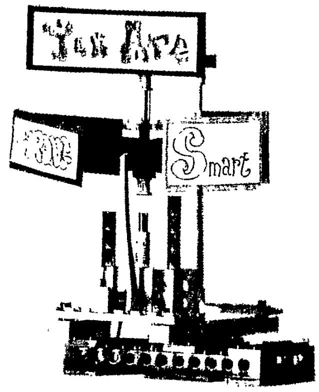

GADGETS GALORE:

Students participating in the lab's community workshops produce all kinds of devices, such as those pictured here.

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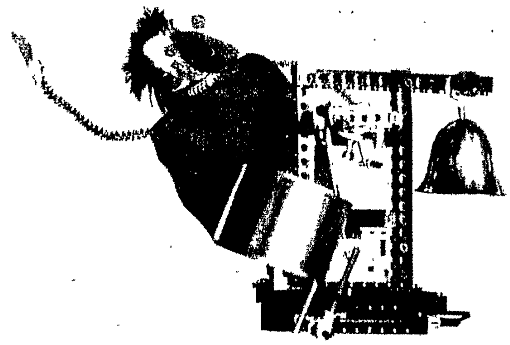
Mitchell Resnick, who oversees the lab's Lifelong Kindergarten group, eyes some "dancing crickets," small Lego vehicles that are programmed to move simultaneously.

d five to 10 years, when now-embryonic technologies determine how the gadgets can be used in education.



As the heart of the Lego Robolab kits for schools and of the popular Lego Mindstorms Robotics Invention system for the home market, the RCX is in classrooms worldwide and used by thousands of children at home, according to Lego Children as young as 8 can make robots that respond to light and touch sensors, and operate motors and machines

■ Yet hundreds of other ideas are also brewing here, such as the assortment of interesting gadgets on display outside Mikhak's office. One is a tabletop stage, made from acrylic panels, which is about the size of the typical student model of Shakespeare's Globe Theater.

But this 32-inch-tall venue is designed so it can actually put on a miniature play, with computer-controlled marionettes made of Legos The stage has operable stage lighting, and a flat-panel computer screen can be positioned behind the back panel to display "scenery" through a rectangular opening. Using "Playmaker," as the setup is tentatively called, students would write a play, direct the action, plan the lighting, and so forth, says Mikhak, a soft-spoken 43-year-old, who, like many of the lead investigators at the Media Lab, was first a graduate student here Mikhak emphasizes the usefulness of the acrylic panels that make up the Playmaker. The material is cheap, easy to shape with cutting tools available in most high school shop classes, and can be assembled into many devices using basic computer hardware. Students following blueprints or their own designs could turn out a wide range of devices, such as the Playmaker or a miniature electronic piano, Mikhak says, gesturing toward an acrylic baby grand nearby that would be the right size for a hamster to play. Built into it is a speaker and a full MIDI soundboard that plays music—sounding like any instrument or even birdcalls—in response to commands from the keyboard or from an RCX

Mikhak also shows two life-size plastic heads with moving lips and eyebrows made of acrylic parts and electronic components. They can be programmed to have a scripted conversation with rudimentary facial expressions, a capability that he believes will encourage children to create dialogue

Making or using any of these devices as a class experience, Mikhak underscores, requires good teaching to generate discussions that bring clarity to the relevant concepts, whether in mathematics, design, research, writing, or drama. Students will be ready to reach for such links, he believes, because they want their projects to work

Mikhak adds that the researchers aren't just dreaming up such devices and trying to sell them to teachers. People from the Media Lab maintain relationships with teachers in a number of places—including Boston, Cambridge, and Watertown, Mass.—and try to support those educators in what they want to do. "The work we do, things we design, is driven by activity that [the teachers] think is worthwhile to do with their kids," Mikhak says

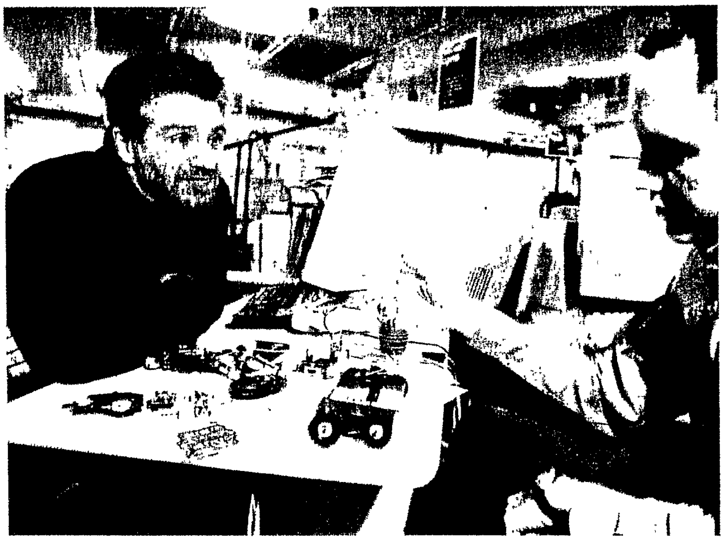
His interest in acrylic construction is matched by Brian Smith's pursuit of the ways in which images can provoke students to question and reflect, as in the Harvard Square photo project The payoff is when the tools yield opportunities for students to think about academic topics in new ways

Smith, who is 32 and grew up in Los Angeles, likes to talk about a project he developed a few years ago as a doctoral student at Northwestern University Together with another researcher, he came up with an interactive video system that allowed students to revamp a commercially produced nature documentary with their own commentaries and selections of images.

They settled on using documentary film because students and teachers are comfortable with the medium. Footage of Serengeti lions hunting prey was digitally stripped of the soundtrack. Students then made their own observations of the animals' behavior, selected clips from the footage, and wrote new narratives based on their observations and research, using a set of software tools called Animal Landlord.

"We wanted students to use the video as data instead of as an information source," Smith says. They tested the system in four weeklong units with about 300 students and 12 biology classrooms. Smith says the unit required special scheduling to fit into the school day.

The students working on the project found that although their technology tools provided a framework for learning, the teacher had to keep students focused on the right concepts, he says. In re-editing the films, students would tend to emphasize the kill at the end of a lion's successful chase, rather than the techniques the big cats used and the fact that most chases are unsuccessful.



"The future of education—who's going
David Cavallo. "Go back 10 years; wh

■ The Media Lab has always had a global mission, which researchers say is suited to the universal nature of information technology and human cognition, and from the more than 21 countries represented among the people who study and work in the lab. David Cavallo's group, the Future of Learning, which is staffed by four research assistants, who are graduate students, and five undergraduates, supports projects in Thailand, Brazil, and Mexico, as well as in the United States. Cavallo says the group leverages its small numbers by working with overseas universities, education ministries, city governments, and schools that agree with its approach to improving teaching and learning. "We don't want [the groups we help to be] dependent on us, so that we have to be there to make something happen," Cavallo notes.

Last summer, the group supported a five-week training session in Mexico City for about 250 teachers from 13 countries and four continents. The lab shipped in 100 computers, 30 robotics kits donated by Lego, and several digital cameras. Then the researchers let the teachers explore how to use the technology to create digital projects. One team of teachers, for example, took images from a visit to the city's Aztec pyramids and used them to make a clay animation video of Mexico's cultural heritage.

Cavallo, who is 50 and married to a Brazilian, says it's crucial to engage in projects that are within the means of the participants—and that are meaningful to them.

One of his group's most ambitious projects to date is in Sao Paulo.

Started last August with a three-week workshop led by Paolo Blikstein, one of the Future of Learning group's graduate students, the project demonstrates that limited local resources can be combined effectively with outside resources. Children at a school in Heliopolis, Sao Paulo's largest slum, were asked to bring in old electronic parts, such as broken radios and tape recorders, from those scraps, they built robotic devices that could be controlled by computers and Lego RCXs supplied by the lab.

The theme of the activity was designing an energy-efficient house, which is related to an important safety issue for these Brazilian children. Many homes in their community are powered by illegal and hazardous connections to public utility poles.

The project went a step further. When the students took a tour of a newspaper office, they hit upon producing their own newspaper focusing on electrical safety.

What has resulted is a rich blend of learning experiences about science and engineering and about journalism and publishing. Plus, the students are performing a community service, Cavallo says.

In November and December, Cavallo and Blikstein returned to the project site, where students are now involved in an activity to redesign the city of Sao Paolo. At every step, the lab researchers have trained the city's school technology coordinators and some teachers, and the project is to be expanded to 55 Sao Paulo schools this spring.

Working in such settings requires that researchers be both humble and observant, Cavallo says. "In thinking about the future of learning, it's not like any of us have the answer," he says, "but what can we do in real places, particularly those that face serious obstacles, that are good experiments in how learning and school can be different, and what you can do with technology."

He adds: "It's not something you can do in the privacy of your laboratory."

To help schools in poor communities, the Media Lab is also trying to push down the cost of computing, says Blikstein, 29, who has a master's degree in electrical engineering from the University of Sao Paulo and is completing another master's at MIT in media and technology.

For a visitor, Blikstein demonstrates the programmable brick's latest descendant: some circuits on a small wood-fiber card. The Go-Go board, as it's called, is not much to look at, but someone with basic electronics skills can make one from a blueprint for $20 in parts. And it does many of the same things as Lego's polished RCX, which costs $120 retail.

The Go-Go board has connections for eight sensors and six ports for sending instructions to other devices. There are plans to develop a version equipped with a GPS receiver for Sao Paulo students to use to sample environmental data on lead residues throughout their city. Another idea is to add two-way radio communication to the devices, Cavallo says.

■ The Media Lab continues to be one of the world's main confectioneries for the Logo family of computer languages, which was first introduced to schools in the 1980s, chiefly through the work of Seymour Papert, a founding faculty member at the lab who more than anyone else has shaped its approach to education. Papert, now 72, still takes an active, though emeritus, role as a mentor to researchers in the Future of Learning group.

Logo was designed to be a programming tool with a "low threshold and a high ceiling"—so even young children could learn to use it, but it would also have great computing capabilities. The basic version allows children to write instructions for a graphical

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Paulo Blikstein, right, an MIT master's student, talks with researcher David Cavallo about how technologies can be customized to meet each student's needs.

object, known as a turtle, that will move about on the computer screen, draw graphics, and perform other tasks as ordered Students in many countries use variants of the language to prepare multimedia presentations and create computer games. Some Logo versions, including Lego's RCX code, control robots.

Since the early 1990s, Mitchel Resnick, a principal investigator with the lab's Lifelong Kindergarten group, has led the development of StarLogo. That version allows children to program instructions for thousands of turtles in parallel Students use StarLogo, for example, to investigate how decentralized masses of individuals, such as commuters in traffic or geese in flocks, appear to respond as if under central direction

New versions and applications of Logo seem to be bubbling in computers in many parts of the Media Lab building

Resnick is also developing a version of Logo for children who cannot yet read

A former science writer who earned a doctorate in computer science at MIT, Resnick, a tall man with a curly beard, was a prime mover in developing the programmable brick that became Lego's RCX. Now he holds MIT's "Lego Papert chair."

His high-ceilinged lab is well-stocked with whole and partly assembled Lego robots, among the computers on tables A turtle-shaped kiddie pool in one corner of the room overflows with random Lego pieces; other Legos are organized in about 20 rows of plastic drawers on one wall.

Resnick is earnest in trying to apply to all ages the essence of kindergarten: learning important ideas through physical activities.

"The kindergarten approach to pedagogy has been difficult [in grades 1 and higher] partly because we didn't have appropriate materials," he says.

Computational materials, though, allow older youngsters to explore more complex ideas, kindergarten-style, he says

Resnick has helped bring that vision to teenagers through the Computer Clubhouse after-school program, which he helped initiate in 1983 in conjunction with the Boston Museum of Science. Thirteen clubhouses have been founded in the U S, plus one each in Colombia and Germany. One hundred more clubhouses—serving an estimated 50,000 students—are being established in poor communities under a five-year grant from Intel Corp., a Media Lab sponsor The clubhouses let students do work—along the lines of the Media Lab itself—with computers, multimedia, and Lego robots and the aid of trained counselors Projects tend to cut across academic boundaries, bridging English, math, the arts, science, and social studies.

The Computer Clubhouses have worked because "they placed a great deal of attention on training to ensure the staff who worked with children have solid training and the necessary knowledge base to carry out what they're supposed to do," says Tracy Gray of the Morino Institute. She says other programs for "after-school learners" have used the clubhouses as a model

After-school programs have the advantage that they sidestep many of the constraints of operating within a regular school program, some lab researchers say Resnick acknowledges that his favorite projects are not easy to do in a regular classroom with one teacher and 30 students Regular school, he notes, is constrained by chopped-up blocks of time in the school day, interruptions for testing, and often-rigid curriculum requirements

"The ideal we're aiming at would require really systematic change," Resnick says. "It won't come about through incremental adjustments."

But he and other researchers say that many teachers still find Lego robotics worthwhile. And Resnick believes that StarLogo "still is and is going to be something that becomes very widespread"

For one thing, regular classrooms have a hard time teaching certain academic topics. "In biology, for example, schools aren't very good at giving students an understanding of the dynamics of an ecosystem, or of the mechanisms by which the immune system works," Resnick says

Both topics have been "excluded from teaching because we didn't have a good way of teaching [them]," he says

But computers excel at modeling environments and demonstrating feedback and control. "The presence of new technology might force us to rethink curriculum," Resnick suggests.

■ For now, though, the Media Lab faces a challenge of maintaining its ideas in U S schools in the face of the reform initiatives of the past decade, in which schools are being brought under the discipline of new academic standards and statewide assessment and accountability systems

Media Lab researchers are acutely aware that those trends have restricted many schools' latitude for allowing students to learn through projects that blend the study of multiple disciplines Some schools have decided that project-based learning is simply a luxury they cannot afford.

In response, the Media Lab has begun correlating its activities for children with academic standards

And researchers are keeping a critical eye on the trend toward more standardized testing

Simply put, standardized tests simply overlook certain kinds of valuable learning, Cavallo says. "The way we do these projects," he says, "we know there's something that happened here—sometimes it shows up in test scores, and sometimes it doesn't"

Cavallo frets that "what we're worried about is making the dialogue about assessment a better and deeper dialogue, and not make it simplistic, which can be harmful to society and drive things in the wrong way"

This spring, groundbreaking takes place for a new Media Lab building, which will double the capacity of the current building Scheduled to open in 2004, it tentatively will house a new center on "bits and atoms" to explore "how the content of information relates to its physical representation, from atomic nuclei to global networks"—and a still-sketchy center on "future arts and expression" It will also host the Okawa Center for the Future of Children and Learning The Okawa Center will include an open lab space that gives researchers opportunities to work with children

Resnick and Cavallo agree that the center will help the lab stay relevant to schools Cavallo says the lab will continue to "open up programming and computational ideas by changing environments so they don't look like programming" and don't require reading to get started

Another area the MIT researchers plan to explore is how mobile electronic devices, such as cellphones, can be used by students to do class projects that complement academic learning

"The future of education—who's going to say what it's going to look like," Cavallo says "Go back 10 years; who predicted the Web?" ■

Coverage of technology is supported in part by the William and Flora Hewlett Foundation.

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predicted the Web?"

Lab researcher Brian Smith specializes in digital imaging and video technologies. He works to put those technologies in the hands of students in K-12 schools.