Professor Neil Gershenfeld directs the Center for Bits and Atoms at MIT, where he also leads the Media Lab’s Things That Think research consortium. His unique laboratory investigates the relationship between the content of information and its physical representation, from developing molecular computers (which led to the first experimental demonstration of a quantum computation), to smart furniture (seen in the Museum of Modern Art and used in automobile safety systems), to virtuosic musical instruments (including a cello for Yo-Yo Ma and a stage for the Flying Karamazov...
An Interview with Neil Gershenfeld

By Richard N. Katz

Brothers). Author of the best-selling books *When Things Start to Think*, *The Nature of Mathematical Modeling*, and *The Physics of Information Technology*, Dr. Gershenfeld has a B.A. in physics with high honors from Swarthmore College and a Ph.D. from Cornell University; he was a Junior Fellow of the Harvard University Society of Fellows and a member of the research staff at Bell Labs.

Richard N. Katz, Vice President of EDUCAUSE, recently talked with Dr. Gershenfeld about his ideas on education, some of his past projects, and his current work and interests.
RICHARD N. KATZ: For someone with a traditional educational background, you appear to have a less conventional approach to advanced education. How would you describe your approach?

NEIL GERSHENFELD: I think of it in a manufacturing metaphor: universities can function like assembly lines, processing students through courses that build up an inventory of education, for the student to draw on based on future demand. But the most advanced manufacturing processes today are returning to their roots in traditional crafts, by building things through flexible workgroups that can rapidly respond to changing needs. Likewise, instead of having labs that support classes, we invert that model to focus much more on creating intellectual workspaces in which students with a range of backgrounds can work together on emerging problems, drawing on classes as needed to fill in the necessary skills. This way they learn what they want to learn, and how to use what they learn, along with acquiring their more formal education. Plus, doing it this way tends to be a whole lot more fun.

KATZ: That may work with MIT’s apparently inexhaustible supply of brilliant students, but what about the rest of the world?

GERSHENFELD: This sort of approach is needed more, rather than less, where there aren’t enough teachers to go around and where too many students fall out of the educational system (or don’t even enter it). Starting from Seymour Papert’s early work, a number of my colleagues have been finding that people are natural learners who have that curiosity trained out of them by the formality of so much of what they’re taught. From inner-city jails to rural villages in developing countries, we’re seeing that ordinary people can learn to do exceptional things if the educational attention moves from the content of a formal curriculum to the tools that can help people find their own solutions to problems that they care about.

KATZ: Can you give me an example?

GERSHENFELD: A dramatic one is Sugata Mitra’s “hole-in-the-wall” project. His information technology institute in India (NIIT) is in New Delhi, and like many other buildings there, it abuts a slum. He decided to take seriously everyone’s anecdotal observation that children are good at learning to use computers, so he literally cut a hole in the wall and put a networked computer into the slum, with no explanation. He found that within hours, kids had figured out—by experimenting—how to use it to surf the Net and were soon organizing ad hoc classes among themselves on using the Internet to access useful information. The biggest limitation is in fact just getting rid of the institute behind the wall; we’re working with the project on ways to package that kind of computing so that it can survive without central support.

KATZ: How did you, as a physicist, come to be working in Indian slums?

GERSHENFELD: The immediate reason is the Media Lab Asia, an ambitious project, based in India, to explore the promise of advanced information technology for addressing fundamental development needs; I’m coordinating the technical advisory group for the project. But the deeper reason is the end of the digital revolution. That succeeded in freeing information from its traditional packaging, which was a good thing, but all of the bits in the world are of no use if they can’t come out to where people live. In academia and industry we’ve neatly separated hardware from software, and computer science from physical science, but many of the most compelling opportunities and problems lie right at the interface where information content meets its physical representation.

KATZ: Like what?

GERSHENFELD: One of the most fundamental examples is the study of quantum computation and communications, looking at what happens to those things when quantum effects become significant. As is now well known, the answers...
GERSHENFELD: Personal fabricators. We joke about a student being able to graduate from our program when his or her thesis is able to walk out of the printer, meaning that it can print not just images but also sensors, actuators, and embedded intelligence. Although that might sound far-fetched, we do have all of the ingredients working in the lab, and we are beginning to tackle the challenge of integrating them. PCs let ordinary people personalize their digital world, moving software innovation from big companies to anyone with an idea and dramatically expanding the information accessible in a classroom. But our physical environment is still produced by machines much like mainframe computers, with small groups of engineers developing products for everyone else. Bringing the malleability of PCs to the rest of the world promises to let ordinary people shape their physical environment to reflect their own wishes and dreams rather than someone else’s. I view a PF as the ultimate educational tool, bridging between discovery and creation.

KATZ: Sounds great. When can I have one?

GERSHENFELD: Not quite yet—their current state is a bit like the first integrated circuits, showing how the technology can work but still a long way from being a microprocessor. But that doesn’t mean that the exploration of the personalization of fabrication has to wait for the machinery to catch up. At MIT, I teach a wildly oversubscribed course, modestly called “How to Make (Almost) Anything.” In advance of the widespread availability of personal fabricators, we provide access to existing industrial production machines for nontraditional users, covering the rapid prototyping of both physical and computational structures. I was wholly unprepared for the response; I had ten students trying to get into the class for every one student that I could take. More significant were their pleas; they said things like “This is the class I’ve been waiting for all my life” and “I never thought MIT would teach anything so useful.” There was in fact an almost illicit pleasure in covering material that was so shamelessly useful. This reaction was so unlike any that I had encountered before that it led me to wonder if there was something wrong with this class—or instead with all the other ones that I teach. I’m beginning to think it’s the latter.

KATZ: When you talk about your work at MIT or about the “hole-in-the-wall” project, you talk about the importance of partners. Care to amplify?

GERSHENFELD: Some of our output comes in the form of journal papers on fundamental research, and some appears in products developed with sponsors. But if we’re not answering to a research community or a marketplace, then we’re careful to make sure that we don’t pose our own problems and evaluate the success of their solutions. There’s a very dangerous space in between, where research doesn’t really answer to anyone. What connects rural India with kids’ playrooms would be educational tools that answer to the needs of those who use them. At MIT, I’ve been waiting for all my life and “I never thought MIT would teach anything so useful.” There was in fact an almost illicit pleasure in covering material that was so shamelessly useful. This reaction was so unlike any that I had encountered before that it led me to wonder if there was something wrong with this class—or instead with all the other ones that I teach. I’m beginning to think it’s the latter.

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in this regard is that they present clear and compelling challenges that require some of the most advanced emerging technologies, and that it's easy to recognize success (and failure).

**KATZ:** Speaking of barriers, how do you expect to gain traction in an area with literally hundreds of dialects and with significant literacy problems?

**GERSHENFELD:** Language barriers are overrated for two reasons. First, we’ve seen that language acquisition is slow if it’s discretionary but that a working language can be acquired very quickly if it’s in the critical path to using a useful tool (like the “hole-in-the-wall” project). And second, computers can acquire people’s languages, rather than asking for the converse, if the machines are given rudimentary means to learn from their users (as my colleague Deb Roy has shown).

**KATZ:** Other than language, what are the barriers that will impede the development of smart communities?

**GERSHENFELD:** First of all, there’s the barrier of the belief that a community’s lack of development should be reflected in a lack of sophistication in the technologies used to help its development. We’re finding that in fact many of these problems need the most advanced rather than the most rudimentary devices, because the local needs are so much more challenging than those in better-developed places. Then there are the conflicts with entrenched interests that might not want to see this happen; a good trick here is to sneak potentially disruptive technology in through a society’s margins (an example is LEGO’s Mindstorms, which is nominally a toy but which really challenges the role of formal curricula in education). And perhaps most essential of all is the integration with micro-entrepreneurial business models, so that the deployment can be self-sustaining.

**KATZ:** One thread that connects your interests in music, smart LEGOs, intelligent paper, smart diaries, quantum computers, and smart Indian villages relates to technologies designed in and for everyday things.

**GERSHENFELD:** For that to be even worth remarking on implies that the more normal converse is to focus on inappropriate technologies. And I believe that this is indeed the case: most technologies are developed by engineers for people they may poorly understand. I think that ordinary people learning how to take over the design of the technologies that they live with may be starting the greatest technological revolution of all time. But it’s going almost entirely unnoticed because the press looks to people like me to see where the future is headed rather than looking in the playrooms or the rural villages where the future is now actually happening.