What determines how well kids do in school?

By applying his expertise in statistical physics to analyze school test scores, Mike Marder discovered two times at which the performances of economically disadvantaged kids take a dive: the transitions to middle school and high school. And, he says, his findings question the commonly held idea that teacher effectiveness is the most important variable in student performance. "Poverty may be more important."

Marder, a physicist in the University of Texas at Austin's Center for Nonlinear Dynamics, and graduate student Dhruv Bansal analyzed five years of Texas standardized math test results, encompassing around 17 million scores of 4.6 million distinct third to eleventh graders from about 8000 schools. They used coarse graining approaches, the Fokker–Planck equation, and, for predictive purposes, Markov models. "All of these concepts have immediate applications for making sense of the patterns of scores," says Marder. For example, he says, "only by putting results in terms of the Fokker–Planck equation do I know how to specify convective and diffusive contributions specifically and uniquely." A convective variable would be "genuine learning, all students get better. The diffusive effect is when [students] guess, or random variations from teacher to teacher. Every phenomenon has some deterministic and some random component. You can capture that with a second order Taylor expansion."

Sample results for 2006 and 2007 are shown in these plots of score versus grade level. The lower plot shows students who were eligible for free and reduced-price school meals, and the upper plot shows those who were not. The tail of each arrow is the average test score for a given 10% interval in 2006, with the arrow's point made up of the same students' scores in 2007. Arrow area is proportional to the number of students. The shading in the plots shows the cutoffs for failing (blue), passing (orange), and commendable (green) performance. The results are similar from year to year. (Figures courtesy of Mike Marder and Dhruv Bansal.)

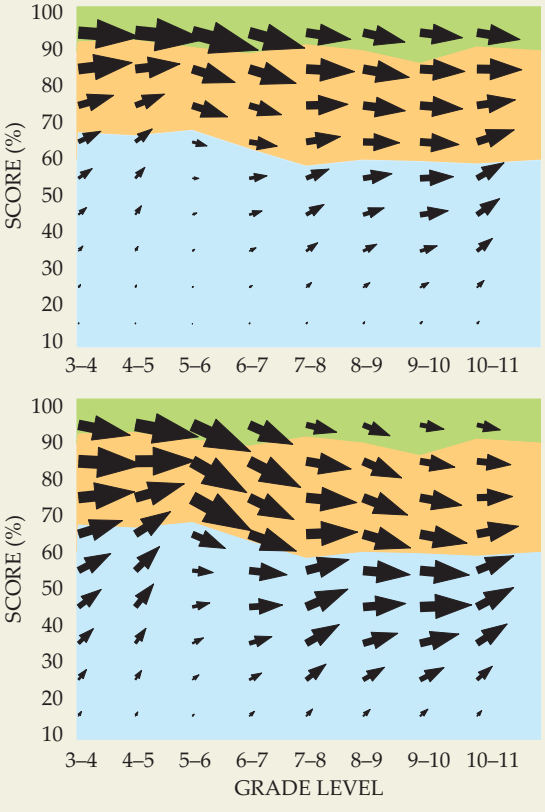
The flow patterns for all students start out similar, "until the transition to middle school between fifth and seventh grade, when students from economically disadvantaged backgrounds flow downwards at a higher pace than their less-disadvantaged counterparts and never recover," Marder and Bansal write in a recent paper (*Proceedings of the National Academy of Sciences USA*, volume 106, page 17267, 2009). Another downward flow is seen at the transition to high school.

"A common claim is that the dominant factor in student performance is the teacher," says Marder, who helped design and run UTeach—the university's program to prepare secondary math and science teachers that was held up as an example by President Obama in a 24 July 2009 speech. "I'm committed to improving teacher quality," says Marder, "but the important question is, Is it enough? I believe our data say otherwise." Income level plays a large role, he says. More specifically, "it's not your income that's so important—the fraction of other low-income families around you is more relevant."

Bolstering Marder's belief that improving teacher quality is not itself enough to boost student performance is the poorer performance in schools that have an increasing percentage of kids eligible for a free lunch. Individual and school-averaged scores on annual tests, the changes in those scores from year to year, and scores on the SAT all follow that pattern, says Marder. "Once the fraction of low-income kids in a high school passes 80%, there is not a single school where more than 20% of graduates get the college-ready SAT score of 1110. Not one," says Marder. "If good teachers alone were actually the most important single factor for student learning, surely at least one school serving disadvantaged kids would have done better than this."

Marder hopes his results reach people who work to improve schools and measure the effectiveness of teachers. "The coming availability of $5 billion in stimulus [American Recovery and Reinvestment Act] funding for school reform makes this a good time for new ideas," he says. "I am hoping that by having orthogonal mathematical tools to look at this problem, we may open space for discussion."

Toni Feder



Congressional fellows tackle a range of national issues

Sweeping US health-care and climate-change reforms, should they become law, will bear the fingerprints of physicists and engineers, thanks in part to an annual fellowship that places scientists in congressional offices or on committees. "If there's ever been a year that you want to be a health-care staffer, it's this one," says biomedical engineer Robert Saunders, who was hired by Representative Rush Holt (D-NJ) in September. Saunders had spent a year on Holt's staff as a congressional fellow sponsored by the Optical Society of America (OSA) and SPIE. Saunders, who helped develop amendments to the House's health-care bill, says the fellowship "is one of the few ways that a bench scientist working in the lab can jump right in to working on the hill."

Some 187 scientists—most of them

PhDs—started their 12-month terms in Congress and the executive branch this summer as fellows of a program managed by the American Association for the Advancement of Science. More than 30 scientific organizations partner with AAAS to sponsor the fellows; the American Institute of Physics (AIP), which also sends a fellow to the State Department (see accompanying story), and some of its member societies are sponsoring seven congressional fellows this year, up two from 2008.

The public option

This year AIP and the Acoustical Society of America cosponsored PhD physicist Jeffrey Fox, who will focus on education policy in the office of Senator Jeff Bingaman (D-NM). Fox says he's learned that in Congress, "it's about knowing how to evaluate what the problem is and who to talk to." Although fellows traditionally gravitate toward science policy, "the health-care debate dominates backroom office discussions" right now, says PhD astrophysicist Marcos Huerta, this year's AIP/AVS congressional fellow, who is working on environmental issues for Rep. Raúl Grijalva (D-AZ). Huerta, who was a volunteer for Barack Obama's presidential campaign, says he'd like to stay on the policy track and may eventually consider running for public office.

"The change in administration has made it an exciting time to be in Washington," says this year's OSA/SPIE fellow, Matthew McMahon, who is on leave from Second Sight Medical Products Inc, a California company that develops visual prostheses for the blind. A PhD experimental psychologist, McMahon is working on space and climate-change issues as a staff member for the Senate Committee on Commerce, Science, and Transportation. Also working on climate-change legislation is midcareer PhD industrial geologist Maeve Boland, a native of Ireland and this year's American Geophysical Union (AGU) fellow. The Clean Energy Jobs and American Power Act, the

Cosmologist heads to the State Department

In 2007 University of Chicago graduate student Matthew Sharp took a break from his research in experimental cosmology to attend a conference of the Union of Concerned Scientists. He says the experience of meeting scientists who contribute to public policy was "like climbing out of a cave and into the sunlight."

Sharp

Now, after analyzing nuclear nonproliferation issues as a postdoc at Harvard University's Kennedy School of Government, Sharp will continue the evolution of his career as this year's American Institute of Physics State Department Fellow. He is working in the Office of Multilateral Nuclear and Security Affairs in the Bureau of International Security and Nonproliferation. A few weeks into the fellowship, Sharp says one thing he has learned is that "meeting deadlines is more important than perfection." He is already looking to extend his fellowship but says he isn't ready to turn his back on physics forever.

Last year's AIP State Fellow Suzanne Koon is now a postdoc in nuclear astrophysics at Oak Ridge National Laboratory. "I wanted to stay on [at State], but given the available opportunities, I chose to return to science [research]," says Koon. Among the highlights of her time at the State Department, she lists travels to Egypt for a conference of the International Association of Geomagnetism and Aeronomy and to Zambia for a workshop in celebration of the International Heliophysical Year. **Jermey N. A. Matthews**

JULIE DEMEESTER

Congressional fellows sponsored by AIP-affiliated societies this year are, from left, Marcos Huerta, Virginia Corless, Jeffrey Fox, Arti Garg, Gavi Begtrup, and Maeve Boland. Not pictured is Matthew McMahon.

flagship US climate-change bill, was introduced on her first day as a staff member for Sen. Byron Dorgan (D-ND), a member of the Senate Committee on Energy and Natural Resources. Boland says she intends to return to her research faculty position at the Colorado School of Mines, where she teaches a seminar on US public policy.

"Everyone's preparing for the climate bill to take center stage," says Virginia Corless, a PhD astrophysicist and one of this year's American Physical Society congressional fellows. Corless, a staffer on the Senate's energy committee, says she didn't come to Congress just to work on energy; she cites education and international science policy among her other committee responsibilities. International policy fits squarely in the portfolio of the other APS fellow, PhD astrophysicist Arti Garg; she joined the staff of the House Foreign Affairs subcommittee on terrorism, nonproliferation, and trade. "I'm interested in all three words," says Garg, who worked as a postdoc at Lawrence Livermore National Laboratory before the fellowship. Unlike academia, she says that Congress is often reactive, so "priorities can change quickly depending on current news."

"How the sausage gets made"

Some new fellows don't have to wait long to witness the excitement of seeing a bill on its way to becoming law. PhD physicist Gavi Begtrup, this year's OSA/Materials Research Society (MRS) congressional fellow, joined the staff of Rep. Gabrielle Giffords (D-AZ) just in time to see the Solar Technology Roadmap Act, sponsored by his new boss, pass in the House. That legislation directs the Department of Energy to appoint a committee to create a 15-year solar technology roadmap and to provide $2.25 billion in solar energy R&D over five years to DOE-managed, industry-led consortia. Begtrup gives credit for the bill's passing to professional staff members such as 2003 APS fellow Adam Rosenberg. Elaine Ulrich, last year's APS fellow, also worked on the bill; she says the process of crafting it was just as satisfying as seeing it passed. "When you get involved and you have a stake in the bill, you'll find yourself rooting for it when it comes up for a vote," says Ulrich, who now works for New West Technologies LLC, where she does policy analysis on energy issues for DOE's Office of Energy Efficiency and Renewable Energy.

Although most fellows leave in August, two of last year's fellows stretched their stays on the hill through November: AGU fellow Maggie Walser continued her work on water and energy policy for the Senate's energy committee, and OSA/MRS fellow Amit Mistry stayed on in the office of Rep. Edward Markey (D-MA), working on health and education policies. Outgoing AIP fellow Richard Thompson returned to the University of Arizona, where he lectures in the geosciences and teaches a course on public policy. During his fellowship, he helped write environmental legislation for Grijalva; he says it was a rewarding experience to participate in policymaking and "interesting to watch how the sausage gets made." Thompson's advice to the new fellows is, "Throw yourself into your work, but don't forget you are living in the most exciting place in the world."

Jermey N. A. Matthews

Congressional fellowship applications are due in early 2010. For details on sponsorship through AIP or its member societies, visit http://aip.org/gov/fellowships.html.

news notes

New role for test site. It appears the Nevada Test Site will finally receive a new mission, 17 years after the last US nuclear test occurred there. The Senate's version of a 2010 appropriations bill for the Department of Defense includes an amendment offered by the state's two senators instructing the Department of Energy to rename the NTS and to officially assign it the new role as the center for verifying nuclear arms reduction treaties.

In the post–cold war years, the 3561-km^2 NTS has been limited to performing tests that produce no nuclear yield. The NTS has also trained personnel on criticality safety and in safeguarding nuclear materials. The site is supposed to maintain the capability to resume nuclear tests within 18 months. But in an interview with the *Las Vegas Sun* earlier this year, Stephen Younger, president of National Security Technologies, the site contractor, said less than 1% of the NTS budget now goes to maintaining that readiness. **DK** ■

web watch

To suggest topics or sites for Web Watch, please visit http://www.physicstoday.org/suggestwebwatch.html. Compiled and edited by Charles Day

http://inisdb.iaea.org

The **International Nuclear Information System** is the online archive of the International Atomic Energy Agency. A recent addition to the archive, which is accessible to the public, is a collection of 180 000 documents from the US Department of Energy's Office of Scientific and Technical Information.

http://www.yale.edu/ynhti/curriculum/units/2003/4/03.04.07.x.html

From the Yale–New Haven Teachers Institute comes **The Physics of Cell Phones**, a curriculum unit, with lesson plans, for teachers in grades 5 through 8. The unit's introductory material provides a primer on cell phones that even PhD-holding physicists will find informative.

http://elementsofhumanity.com

In **Elements of Humanity**, 12 scientists and engineers speak informally in front of a video camera about their research and about what inspired them to choose their careers. The photo shows one of the interviewees, Drexel University's Andrew Hicks, reflected in a nonreversing mirror that he designed. *Make* magazine created the website.