of-life conversations should be treated like any other competency, such as placing a central line or choosing appropriate antibiotics for pneumonia. An attending physician should model the skill, then watch trainees and offer feedback. Prognostication should similarly become a required skill. For instance, every initial admission of a seriously ill patient should include an assessment of prognosis alongside the plan for each organ system. Assessments should be discussed on rounds, and residents should be required to follow up to determine their accuracy.

Of course, leading these conversations requires some skills that are difficult to teach, such as intuiting the responses of patients and families. Nevertheless, Kenneth Prager, director of clinical ethics at Columbia University Medical Center, says education remains imperative. He categorizes trainees into three groups: naturally good communicators, poor communicators, and a middle third who simply need proper instruction.

Some attendings model these conversations for their teams and offer tangible advice. For instance, recognizing our tendency to shy away from death, Aaron Waxman, an intensivist at Brigham and Women's Hospital, insists that each conversation include the words "death," "dying," and "dead." Rather than try to dissuade patients from choosing resuscitative measures by stressing their potential brutality, Waxman chooses to focus on ways the physician can help to promote comfort. Through his example, he teaches residents that patient autonomy is not synonymous with endless choice.

These conversations won't get any easier. The population is aging. Hospitalists have assumed the care of patients who would once have been followed by their longtime physicians. Work-hour reform increasingly erodes residents' relationships with inpatients. And with medical advances such as extracorporeal membrane oxygenation, ventricular assist devices, and transplantation, there's almost always something else we could offer.

Franz Ingelfinger, a former editor of the *Journal* who died of esophageal cancer, wrote an essay that the *Journal* published posthumously, in 1980, about what he sought from his own physicians at the end of life. He wrote, "A physician who merely spreads an array of vendibles in front of the patient and then says, 'Go ahead and choose, it's your life,' . . . does not warrant the somewhat tarnished but still distinguished title of doctor."

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

Drs. Lamas and Rosenbaum are editorial fellows at the *Journal*.

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BECOMING A PHYSICIAN

Lecture Halls without Lectures — A Proposal for Medical Education

Charles G. Prober, M.D., and Chip Heath, Ph.D.

The last substantive reform in medical student education followed the Flexner Report, which was written in 1910. In the ensuing 100 years, the volume of medical knowledge has exploded, the complexity of the health care system has grown, pedagogical methods have evolved, and unprecedented opportunities for technological support of learners have become available. Yet students are being taught roughly the same way they were taught when the Wright brothers were tinkering at Kitty Hawk.

It's time to change the way we educate doctors. Since the hours available in a day have not increased to accommodate the expanded medical canon, we have only one realistic alternative: make better use of our students' time. We believe that medical education

can be improved without increasing the time it takes to earn a medical degree, if we make lessons "stickier" (more comprehensible and memorable) and embrace a learning strategy that is self-paced and mastery-based and boosts engagement.

Research has elucidated the factors that make ideas sticky.[1] For instance, messages are stickier when they are unexpected enough to capture our curiosity.

Consider this excerpt from a recent "Case Records of the Massachusetts General Hospital": "A 37-year-old man was admitted to this hospital because of muscle pain and weakness. The patient had been well until the evening before admission, when mild diffuse myalgias developed. He awoke in the morning with diffuse muscle cramps and intense pain in his legs. . . . On arising to go to the bathroom, he felt unsteady and had difficulty walking. After he returned to bed, diffuse muscle pain persisted, with weakness in his arms and legs and numbness in his legs; he was unable to arise again."[2]

Do you want to learn more? That's the power of the clinical scenario. The case's discussant reflects on the differential diagnosis that might explain this acute onset of weakness and pain, including inflammatory, infectious, toxic, metabolic, and autoimmune processes. A single such case could serve as the lead-in to multiple medical school topics that might otherwise seem dry and routine.

The goal is to time the story to captivate learners and underscore the relevance of knowledge they've recently acquired or that's about to be conveyed. Medical educators might take a cue from pop culture: even laypeople love medical mysteries, imbibing them in the form of television shows like *House* and *Grey's Anatomy* or from the *New York Times* "Diagnosis" column. When possible, we should seize that curiosity — the perfect fuel for learning.

Messages also become stickier when they come in the form of a story that elicits emotion in readers or listeners. Patients' stories are what make the acquisition of medical knowledge compelling. They serve as the scaffolding on which facts and concepts can be organized and reinforced. As Sir William Osler aptly said, "He who studies medicine without books sails an uncharted sea, but he who studies medicine without patients does not go to sea at all." Yet conversations with medical students about the first-year medical curriculum reveal that about half of lectures proceed without even the briefest example involving patients.

Attention to stickiness would make medical school lectures more engaging and memorable, but they would still be lectures. We think a more radical and important strategy is to move those lectures outside the lecture hall and to use class time for more active learning.

For most of the 20th century, lectures provided an efficient way to transfer knowledge. But in an era with a perfect video-delivery platform — one that serves up billions of YouTube views and millions of TED Talks on such things as technology, entertainment, and design — why would anyone waste precious class time on a lecture? We propose embracing a flipped-classroom model, in which students absorb an instructor's lecture in a digital format as homework, freeing up class time for a focus on applications, including emotion-provoking simulation exercises. Students would welcome more opportunities for case-based, problem-based, and team-based exercises — strategies that activate prior knowledge. Teachers would be able to actually teach, rather than merely make speeches.

Digital media make video lectures relatively easy to create, offer flexibility so that students can watch at their own pace and on their own schedule, and are popular with learners. For example, the Khan Academy, a nonprofit organization that offers online video lessons and exercises on elementary and high school topics, allows students to gain proficiency in core academic concepts at their own pace. If such a model were applied to medical school, class time would be freed up for higher-order and more interactive lessons. Teachers could track each student's progress and use that knowledge to inform focused, customized interactions with small groups of students. Recently, this approach was embraced by a public school district and several charter schools in Silicon Valley, and experience with this educational model has grown to encompass a broad range of content areas and learners. The Khan Academy has produced more than 2700 videos that are viewed monthly by more than 3.5 million students who perform more than 2 million online exercises each day.

This year, our core biochemistry course at Stanford Medical School was redesigned following this model; rather than a standard lecture-based format, the instructors provided short online presentations. Class time was used for interactive discussions of clinical vignettes highlighting the biochemical bases of various diseases. The proportion of student course

reviews that were positive increased substantially from the previous year. And the percentage of students who attended class shot up from about 30% to 80% — even though class attendance was optional.

Evidence is accruing that online instruction is effective and scalable. For example, Stanford's computer science department has shifted several courses to instruction using 10-to-15-minute video segments with embedded quizzes to engage learners and test their comprehension. Professors use class time to challenge students with hands-on exercises, and class attendance has increased substantially. Off campus, three computer science courses, offered free, have been viewed by more than 350,000 enrollees from around the world.

Freeing up class time does seem to make a difference. In a recent study, researchers compared two sections of an undergraduate physics course that had a large enrollment.[3] The first section used the traditional lecture model and was taught by a Nobel Prize–winning physicist. In the second section, which was led by teaching assistants, students grappled with real physics problems as they might be encountered by a practicing physicist. The students in the second, active-learning section were more engaged (as assessed by their course ratings) and more likely to attend class, and their scores on a course test averaged 74%, as compared with 41% among students in the traditional lecture section. A meta-analysis published by the Department of Education has concluded that "on average, students in online learning conditions performed modestly better than those receiving face-to-face instruction," with larger effects if the online learning was combined with face-to-face instruction.[4]

That's the vision that we want to chase: education that wrings more value out of the unyielding asset of time. There are limits to the amount we can lengthen class periods and the additional homework we can assign, but we can use our limited time in ways that boost engagement and retention. Imagine first-year medical students learning critical biochemical pathways by watching short videos as many times as necessary in the comfort of their personal learning space. Knowledge acquisition is verified by repeated low-stakes quizzes. Then, in class, the students participate in a discussion that includes a child with a metabolic disease, his or her parents, the treating clinician, and the biochemistry professor. The relevant biochemistry — so dry on the page of a textbook — comes to life. The lesson sticks.

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Looking beyond Translation — Integrating Clinical Research with Medical Practice

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One area of amazing recent medical advances has been childhood cancers, for which survival rates have quadrupled over the past four decades and now exceed 80%. This progress has been driven not only by the introduction of novel therapies but also by the remarkable level of patient and physician participation in the clinical research process. The robust clinical trial enterprise for this patient population may offer a model for improving outcomes in other age groups, populations, and conditions. The success stems largely from the Children's Oncology Group, a cooperative clinical research group that includes more than 5000 U.S. pediatric cancer specialists. Ninety percent of U.S. children with cancer receive care in centers affiliated with this network, and more than 60% of children with cancer are enrolled in clinical trials. This engagement permits rapid evaluation of new therapies, including delineation of appropriate subpopulations, which