Technology-enabled education (TEE) is education made possible for the first time by new technology. Until recently, the largest single contribution to TEE was Gutenberg’s invention of the printing press in 1450. Printing allowed books to move from the controlling purview of monks to the masses, illuminating the written words of scholars and writers for millions and, ultimately, billions of readers.

Moving forward 500 years, the past 15 to 20 years have seen a barrage of new technology in the form of desktop computers, multimedia, and the Internet. There is little disagreement that new technology will have a huge impact on education. Books, for instance, are now available totally in bits and bytes — no paper. Lectures are accessible via streaming video over the Internet — no classroom. Homework and exams can be graded by software — no professor. Many of the things we ordinarily do in education have been “ported to the Web.”
Stagecoaches Attached to Steam Engine (Mohawk and Hudson, 1831)\textsuperscript{1}

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Is this the best use of new technology in education? Do students want to sit in front of their computer screens and watch a video lecture for 55 minutes? Do they want to read a book on the computer? Would they benefit from instructor-written evaluations of homework and exams?

The dominant educational model from elementary school through higher education has not changed significantly for centuries. Instructors lead classroom teaching from a syllabus that students march through in lockstep. The teacher broadcasts educational “content” or “material” to the students. Testing assures that an appropriate amount of content is transferred, retained, and understood. This pedagogic model also dominates Web-based education today because the old methods are what we know, and we need time to identify and adopt the capabilities enabled by new technology.

History is replete with examples of old methods being ported to the latest technology. One of the first steam engine railroad locomotives in the U.S., operated by the Mohawk and Hudson Company, on its inaugural journey in 1831 traveled
13 miles on new track from Albany to Schenectady hauling three stagecoaches, with horses removed and track-appropriate rims added to the wheels (see the figure). No one had had time to design “railroad cars” to match the new technology of the steam-powered locomotive. Stagecoaches were also familiar, and the train actually traversed a previous stagecoach route.

Another example is motion pictures. With the invention of moving pictures in the early 20th century, the first dramatic films were of plays on the stage. No one realized until much later that the camera and actors were no longer constrained by time and space as in the theater, and everyone felt comfortable with theatrical drama. With the invention of streaming video on the Internet in the 1990s, the first video instruction involved lecturers acting as “sages on the stage.” Few realized that the traditional classroom, with its “chalk and talk,” taking of notes, and passive listening style for students no longer imposed a constraint. Everyone felt comfortable with lecturing as usual.

With Web technology we can easily haul stagecoaches — we’ve used them in the classroom for centuries. In fact, streaming video lectures are a type of ultra-modern stagecoach. So are Web pages — many, if not most, educational Web pages are text-intensive. When color graphics are added, the look and feel mimics that of the Sunday newspaper color supplement.

So, the question isn’t, “Which technology should we use to educate students in the Internet
Any combination of technological tools simply offers another model of a modern steam locomotive. We could haul stagecoaches with any of them. The real question is, “How should we use these technological tools to create new and compelling learning environments?” The challenge is to design and build entire trains, with new railroad cars compatible with the technology that powers them down the tracks. No single design will suffice. Experience and experimentation show that different circumstances require different designs.

Take streaming video over the Web, for example. “Talking head” lectures are the traditional “iron horse” of educational delivery. As one modest step, traditional lectures offered by asynchronous streaming video could be combined with live audio mentoring sessions over the Internet. These live sessions would focus on an instructor responding to individual student questions. Students would meet at the same time, but at different locations; everyone would attend the class via the Internet. This approach would leverage the multi-year shelf life of “high production value” lectures and free up the instructor’s time to interact more closely with students.

As an additional step, the instructor could create an online video tutor. Here, the instructor could sit before one or two video cameras and create asynchronous video discussions with students, resulting in short video segments about difficult con-
ceptual issues, presenting alternative derivations of results, and working through illustrative homework problems. At MIT, we’ve created these for both freshman core subjects and for corporate learners. With online video tutors, students select the video segments they need, as content is easily searchable and retrievable using keywords and a relational database package. This online behavior is very similar to how students select questions to ask their instructor in an office conversation – if they’re lucky enough to get an appointment with an instructor teaching a course with hundreds of students.

An instructor on video need not be limited by the constraints of the campus. For instance, at MIT we have created an educational series on scientific measurements in which the instructor climbs Mount Washington in New Hampshire, flies an airplane and a helicopter, and visits the National Bureau of Standards, each time performing sophisticated scientific measurements. The outtakes resemble the broadcast quality of network educational programming. As learning technology creates richer, commercial-quality visual experiences, expectations of learners will rise, putting severe pressure on the old, handcrafted style of preparing educational materials.

These examples bring us to the designs of the classic railroad cars of the early 20th Century: Pullman coach cars, sleeper cars, mail cars, freight cars, even cabooses. With imagination and creativity, much more can be done. Consider your own son or daughter transfixed by a virtual reality video game. In such an environment your child faces some force and attempts to achieve some goal, perhaps within a limited time or resource window. All the while, he or she is learning, at the least, hand-eye coordination and often much deeper concepts, such as the impact of early urban design decisions on a simulated city. Academically, such an intense environment is called goal-oriented, nonlinear experiential learning. This is the TEE method of choice among several large corporations.
At one Fortune 100 Company new hires in finance must work in this type of environment to design and implement a new line of business that must turn a profit for the firm within 24 months. Failure to do so may result in lack of employment. This total immersion in a simulated environment leads to rapid and deep learning of important concepts reinforced by experience. Such environments often use streaming video to create short video “conversations” with one’s co-workers or co-conspirators. First the simulated person speaks via streaming video, then the learner has one of a finite number of verbal responses, to which the simulated person responds again in streaming video, and so on. This isn’t your typical talking-head lecture. It’s not a caboose. The variety and reality bring to mind a circus train, filled with both exotic and domestic animals of all sorts, each of which we experience as we move along the train.

Other video-intensive pedagogical models are equally as interesting and provide goal-oriented, nonlinear, experiential learning. The point is that the technology can be used in any number of ways. Our challenge is to identify new pedagogical methods that are more effective than the traditional and the comfortable, and to work and play with them until we create the next generation of learning.

Somewhat ironically, the Mohawk and Hudson 1831 steam locomotive was named in honor of former Governor of New York DeWitt Clinton (1769–1828), shortly after his death. During his lifetime, Governor Clinton was known as the father of the Erie Canal and, generally, of canal transportation in the U.S. Railroads brought the demise of the canal system in the U.S. Internet-era technology has the potential to create entirely new modes and businesses of learning, yet it’s unlikely that we will, in the foreseeable future, experience the demise of traditional classroom teaching and learning. Still, we may...
see healthy competition for it. First, though, we must design the railroad cars.

**NOTES**


2. Roger C. Schanck is often credited with being the father of this pedagogy.

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