A New Culture of Teaching for the 21st Century

To maximize the benefits of technological innovation, we need to change the way we think about teaching in K-12 schools

By Stone Wiske

Popular views of educational technology tend to exaggerate both its promise and its peril. Advocates tout computers and the Internet as instant remedies for dry curriculum and didactic instruction in schools. Alarmists worry that computers will replace teachers and that the World Wide Web will poison the minds of young people. Both extreme positions place too much emphasis on the technology itself. People—especially teachers—shape the impact of computers in schools more than the features of hardware and software. If we want to understand how to improve learning in schools, we need to pay more attention to the conditions affecting the culture and profession of teaching.

Certainly, interactive, networked, portable technologies have potential as educational tools beyond that of static materials like pencils and books, or broadcast media like radio and television. When used by knowledgeable teachers in a supportive educational context, these new technologies can significantly enhance teaching and learning.

Moving beyond "Plug and Chug"

The story of graphing calculators is an instructive example. These handheld computers are becoming standard equipment in many U.S. mathematics classrooms. These advanced calculators have a small screen that displays mathematical functions in graphical form as well as in tables and formulas. They allow students to spend less time doing routine calculations, solving equations, and plotting graphs, and more time comparing mathematical functions, predicting the effects of variables, and making sense of representations of mathematical data. They are so inexpensive that many schools can afford to buy whole sets for their classes so that each student has one to use.

In recent years, mathematics textbooks have changed to incorporate calculator-based lessons, and the College Board has begun to permit students to use graphing calculators while taking the SATs. Teachers are gradually learning how to modify both the mathematical content of their curriculum and their approach to teaching to take advantage of these calculators. Some schools have equipment that links calculators to sensors for collecting data such as temperature, pH, movement, and light. The calculators can plot these data as a function of time and graph the results. They can also be connected to equipment that projects the work from any one calculator to a display so that everyone in the class can see it. In these ways, graphing calculators can support inquiry, thinking, and dialogue about mathematics and scientific data, rather than the "plug and chug" routines that have characterized U.S. mathematics classrooms.

What can we learn from this example about the conditions that enable technology to have important educational effects?

- First, the technology must afford significant educational advantage. In this case, calculators allow users to analyze mathematical information by manipulating linked representations such as formulas, graphs, and tables—an essential aspect of mathematical inquiry that is cumbersome with traditional tools of pencil and paper or chalk and blackboard.
- Second, the technology must be readily affordable, networked, and portable. As long as technology is expensive and difficult to move—like most computers—its impact in schools will be limited.
- Third, technology alone does not change school practice. Curriculum goals and materials, assessment policies, and teacher development must shift as well. Without these changes, a new technology will merely be used to enact traditional practices.

This last condition—changing the culture of education—is the most difficult to achieve. How did all these variables—texts, tests, and teachers—shift to support the integration of graphing calculators? Much of the impetus was provided by the National Council of Teachers of Mathematics (NCTM). This professional organization represents a wide spectrum of people interested in mathematics education: mathematicians, teacher educators, curriculum specialists, and classroom teachers. During the 1980s the NCTM worked collaboratively with all these groups to develop new standards for mathematics curriculum, pedagogy, and assessment. Several leaders of this movement had learned from the failure of the New Math reforms of the 1960s. This time they took care to build consensus with parents, teacher organizations, and policy-makers about the new standards.

The NCTM standards, issued in 1989, shifted the focus of the mathematics curriculum from rote rehearsal of isolated facts and formulas to investigating, communicating, and applying core mathematical concepts and habits of mind. Shortly thereafter, the NCTM issued complementary standards for the preparation of mathematics educators. In the ensuing decade, many state education agencies enacted compatible curriculum and assessment requirements. The National Science Foundation funded a series of "systemic" initiatives to support teacher preparation and development in line with the NCTM standards. Textbook publishers prepared new editions that reflected the new standards. This combination of initiatives supported concurrent changes in educational goals, professional development, and curriculum materials that were synergistic with the opportunity afforded by the new technology of graphing calculators.

Rethinking Traditional Teaching Patterns

This relatively encouraging story is not a cause for unbridled celebration, however. Despite the confluence of conditions supporting reform of mathematics education, U.S. classrooms have not changed quickly to resemble the NCTM ideals.

In their recent book *The Teaching Gap,* James Stigler and James Hiebert examine the results of the Third International Mathematics and Science Study (TIMSS), which compared mathematics and science achievement among fourth, eighth, and twelfth graders in 41 nations. The TIMSS data were collected in the mid-1990s, when the impact of NCTM reforms was only beginning to be felt in classrooms. Indeed, some have argued that these data should be regarded as a baseline against which to compare the results emerging from classrooms that enact practices consistent with NCTM standards.

Meanwhile, the TIMSS data are sobering. As Stigler and Hiebert put it, "The results are dramatic, and they do not paint a flattering picture of American education." Twenty nations, including Singapore, Korea, Japan, Canada, and France, scored significantly higher than the United States in eighth-grade mathematics. Only seven nations scored significantly lower than the United States.

Part of the study involved making videotapes of eighth-grade mathematics classes in three countries: Germany, Japan, and the United States. A panel of mathematics educators analyzed these videotaped lessons (and translated transcripts). The panel noted striking differences in the standard practices of the three countries. Japanese teachers typically engage their students in working on challenging problems, and then students share and discuss their solutions. Teachers of German students—whose scores were statistically comparable to those of U.S. students—typically lead students through advanced procedures for solving challenging problems.

In the typical U.S. lesson, however, students first watch their teacher solve low-level problems and then repeat the procedure on numerous similar problems. Whereas the tapes from Japan and Germany reveal that three-fourths of teachers develop concepts during a lesson, most U.S. teachers simply state concepts. The typical U.S. lesson places greater emphasis on memorizing facts and formulas than on understanding the underlying rationale. U.S. students usually follow the teacher's lead, while their Japanese counterparts spend much of their lesson doing challenging mathematics.

These patterns of pedagogy, Stigler and Hiebert conclude, are part of culturally embedded systems. Shifting classroom practice from routine rehearsal of skills toward higher-order thinking, independent inquiry, and sustained work on challenging problems is not a simple matter of introducing teachers to new technology or techniques. Learning to teach is less like learning to use a computer than like learning how to participate in family dinners: teaching is learned through watching and engaging in the approaches that one is expected to emulate. Pedagogical approach is bound up with a web of cultural assumptions. Each country has its own scripts for what happens in the classroom.

Enacting these scripts may include customary props or technologies. In Japan, teachers write copious notes on the blackboard as they explain concepts, producing a record of their main points that students can review. In contrast, the most common teaching technology in U.S. eighth grades is the overhead projector. U.S. teachers move on to a new transparency when they move to a new point. These technologies give students a different experience of the lesson: the Japanese blackboard offers a sustained and coherent picture, whereas the U.S. overhead projector provides an ephemeral and disjointed glimpse of the teacher's agenda.

Culturally embedded teaching patterns are difficult to change, but change is not impossible. Japanese teachers have made a major shift from the whole-class instruction and recitation that used to be their norm. Stigler and Hiebert report that this reform took several decades and required a systematic approach to educational change, including explicit learning goals for students, a shared curriculum, supportive administrators, and sustained efforts by teachers to make gradual improvements in their practice.

To change school practice, curriculum goals and materials, assessment policies, and teacher development must shift. Without these changes, a new technology will merely be used to enact traditional practices.

Stigler and Hiebert describe the Japanese system of change, which features school-based professional development focused on "lesson study." Groups of teachers meet over extended periods of time to develop, try out, and assess lessons. First the group defines a problem of practice and plans an approach to this problem in the context of a particular lesson, usually with a specific hypothesis in mind. Then the group members teach the lesson to their students and meet to discuss how it worked and how it might be improved. Once group members have developed an effective research lesson, they share it with other teachers. Because the entire country teaches the same curriculum, many teachers can benefit from this intensive study of a single lesson. Japan's new culture of teaching has developed through teacher-led research, collaboration, dialogue, and collegial exchange in the very schools where teachers work.

If we want new technologies to foster significant changes in the content and process of learning, we need to devise ways of changing the professional culture of teaching. Changing curriculum standards and materials, revising assessment devices and policies, supplying schools with technical infrastructure, and hiring appropriate technical personnel will all be necessary but not sufficient. We will also need to change the terms and focus of dialogue in schools to encourage talking about subject matter and learning. We will have to change the norms of professional collaboration so that observing colleagues, exchanging curricula, conducting rigorous classroom research, risking failure, and celebrating success become familiar patterns in school workplaces. Only then will teaching become a "true profession," as Stigler and Hiebert advocate, in which "the wisdom of the profession's members finds its way into the most common methods. The best that we know becomes the standard way of doing something."

How can we provide time for this kind of professional dialogue? In Japanese schools, the schedule is organized so teachers have time to meet with one another. Some U.S. schools have also redesigned their schedules so teachers can meet with colleagues to plan curriculum, exchange strategies, and analyze best practices. Educators are also exploring the use of new technologies to extend teachers' opportunities for collegial exchange about their subject matter and about effective practices. Stigler and Hiebert recommend that effective examples of classroom practices be videotaped, digitized, and annotated. A collection of such examples could allow teacher study groups to anchor their conversations in analysis of real classroom interactions. A one-hour video selected from the TIMSS tapes entitled "Eighth-Grade Mathematics Lessons: United States, Japan, and Germany" is now being used by professional development groups around the country.

It Takes a Cyber-Village . . .

The Internet offers a more interactive means of connecting teachers with multimedia resources, peers, and professional development leaders. For example, two web-based projects at the Harvard Graduate School of Education connect teachers and professional developers with research-based resources, teacher-designed curriculum models, and forums for collegial exchange. *Active Learning Practices for Schools* (ALPS) aims to support teachers in using educational approaches developed through research at Harvard's Project Zero. *Education with New Technologies* (ENT), developed at the Educational Technology Center at Harvard by faculty and graduate students, uses a research-based framework called Teaching for Understanding as a structure for integrating new technologies with practice.

The Teaching for Understanding framework guides educators to focus on four elements in helping students develop flexible and robust understanding, not just memorize facts and formulas. The elements are generative curriculum topics, clear understanding goals, performances that cause students to stretch their minds and apply their knowledge, and ongoing assessment using public criteria linked to goals. New technologies can enrich each of these elements; at the same time this framework helps educators clarify how to design and assess effective applications of these new tools.

ENT is intended to support collaborative groups of educators interested in using new technologies to support teaching for understanding. Designed around the metaphor of a village, this online environment includes a meeting hall where participants may confer, a resource library, a learning center offering online courses, and a gallery with detailed "pictures" of effective curriculum designs. The gallery incorporates lesson materials, student work, and reflections by teachers and students about the process of teaching for understanding. In the future, it will include video selections along with guides for study groups.

ENT also features a workshop where teachers can develop and discuss technology-enhanced lessons. Using the Collaborative Curriculum Design Tool, participants may work alone or with a team, communicating through an electronic message system that links to their e-mail. This interactive tool guides teachers to use the four elements of the Teaching for Understanding framework as they develop curriculum. Educators learn to develop generative curriculum topics—that is, topics that address important concepts in their subject matter, engage students' interests, and invite inquiry into related ideas. The tool also helps curriculum developers spell out specific goals for understanding: What exactly are students expected to learn, and why? Users then design a sequence of active-learning tasks that will enable students to meet those goals and demonstrate their understanding. Finally, the design tool supports the development of ongoing assessments that both improve and prove students' mastery of key goals.

Using this tool, educators are guided to apply new technologies in ways that enhance one or more of these elements of Teaching for Understanding. With this guidance, links to related resources, and an electronic communication system to support collegial exchange, the Collaborative Curriculum Design Tool enables educators to study and develop effective lessons, much as the Japanese teachers do in their study groups. Once teams test and refine a curriculum unit, they may publish it online so that others may replicate or adapt it. Shared units deal with a wide range of topics, such as developing literacy using web-based resources to communicate with local lawmakers and understanding the Pythagorean theorem through mathematical inquiry with software.

Integrating new technologies need not require radical change in educational goals and methods. Indeed, teachers often start by incorporating new tools into familiar practices. But even modest beginnings benefit from opportunities to see good examples, talk with like-minded peers and advisers, and gain easy access to resources.

In online learning environments teachers can surmount the barriers of time and distance to communicate, reflect, and collaborate with colleagues. As powerful, networked, portable computers become more readily available, these new technologies may help to foster the development of a professional culture among teachers. Such a culture of continuing inquiry into effective practice is necessary if we are to reap the potential benefits of new educational technologies.

For Further Information

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