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Technology in Education: An Overview

In this 2015 photo, third grader Iyana Simmons works on a coding exercise at Michael Anderson School in Avondale, Ariz. —Nick Cote for Education Week

By Benjamin Herold (@BenjaminBHerold)

Technology is everywhere in education: Public schools in the United States now provide at least one computer for every five students. They spend more than $3 billion per year on digital content. Led by the federal government, the country is in the midst of a massive effort to make affordable high-speed Internet and free online teaching resources available to even the most rural and remote schools. And in 2015-16, for the first time, more state standardized tests for the elementary and middle grades will be administered via technology than by paper and pencil.

To keep up with what's changing (and what isn't), observers must know where to look.

There's the booming ed-tech industry, with corporate titans and small startups alike vying for a slice of an $8 billion-plus yearly market for hardware and software. Much attention is also paid to the "early adopters"—those districts, schools, and teachers who are making the most ingenious and effective uses of the new tools

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at their disposal.

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But a significant body of research has also made clear that most teachers have been slow to transform the ways they teach, despite the influx of new technology into their classrooms. There remains limited evidence to show that technology and online learning are improving learning outcomes for most students. And academics and parents alike have expressed concerns about digital distractions, ways in which unequal access to and use of technology might widen achievement gaps, and more.

State and federal lawmakers, meanwhile, have wrestled in recent years with the reality that new technologies also present new challenges. The rise of "big data," for example, has led to new concerns about how schools can keep sensitive student information private and secure.

What follows is an overview of the big trends, opportunities, and concerns associated with classroom technology. Links to additional resources are included in each section for those who would like to dig deeper.

What Is Personalized Learning?

Many in the ed-tech field see new technologies as powerful tools to help schools meet the needs of ever-more-diverse student populations. The idea is that digital devices, software, and learning platforms offer a once-unimaginable array of options for tailoring education to each individual student's academic strengths and weaknesses, interests and motivations, personal preferences, and optimal pace of learning.

In recent years, a group of organizations including the Bill & Melinda Gates Foundation, the Michael and Susan Dell Foundation, and EDUCAUSE have crafted a definition of "personalized learning" that rests on four pillars:

- Each student should have a "learner profile" that documents his or her strengths, weaknesses, preferences, and goals;
- Each student should pursue an individualized learning path that encourages him or her to set and manage personal academic goals;
- Students should follow a "competency-based progression" that focuses on their ability to demonstrate mastery of a topic, rather than seat time; and,
- Students' learning environments should be flexible and structured in ways that support their individual goals.

How does technology support that vision?

In many schools, students are given district-owned computing devices or allowed to bring their own devices from home. The idea is that this allows for "24-7" learning at the time and location of the student's choosing.

Learning management systems, student information systems, and other software are also used to distribute assignments, manage schedules and communications, and track student progress.

And educational software and applications have grown more "adaptive," relying on technology and algorithms to determine not only what a student knows, but what his or her learning process

is, and even his or her emotional state.

For all the technological progress, though, implementation remains a major challenge. Schools and educators across the country continue to wrestle with the changing role of teachers, how to balance flexible and "personalized" models with the state and federal accountability requirements they still must meet, and the deeper cultural challenge of changing educators' long-standing habits and routines.

Despite the massive investments that many school systems are making, the evidence that digital personalized learning can improve student outcomes or narrow achievement gaps at scale remains scattered, at best.

Additional resources:

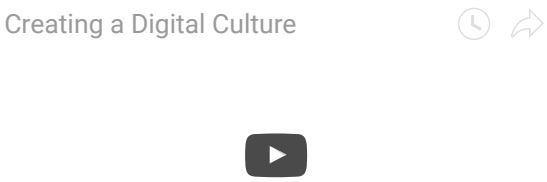
- **Taking Stock of Personalized Learning (*Education Week* special report)**
- **A Working Definition of Personalized Learning**
- **Why Ed Tech Is Not Transforming How Teachers Teach**

What Is 1-to-1 Computing?

Increasingly, schools are moving to provide students with their own laptop computer, netbook, or digital tablet. Schools purchased more than 23 million devices for classroom use in 2013 and 2014 alone. In recent years, iPads and then Chromebooks (inexpensive Web-based laptops) have emerged as the devices of choice for many schools.

The two biggest factors spurring the rise in 1-to-1 student computing have been new mandates that state standardized tests be delivered online and the widespread adoption of the Common Core State Standards.

Generally, the hope is that putting devices in the hands of students will help with some or all of the following goals:



Todd Wirt, principal at Mooresville High School in Mooresville, N.C., Discusses the school's 1-to-1 program and how technology has affected the school's culture. **View more ed-tech videos.**

- Allowing teachers and software to deliver more personalized content and lessons to students, while allowing students to learn at their own pace and ability level;
- Helping students to become technologically skilled and literate and thus better prepared for modern workplaces;
- Empowering students to do more complex and creative work by allowing them to use digital and online applications and tools;
- Improving the administration and management of schools and classrooms by making it easier to gather information on what students know and have done;
- Improving communications among students, teachers, and parents.

Despite the potential benefits, however, many districts have run into trouble when attempting to implement 1-to-1 computing initiatives. Paying for the devices can be a challenge, especially as the strategy of issuing long-term bonds for short-term technology purchases has come into question. Many districts have also run into problems with infrastructure (not enough bandwidth to support all students accessing the Internet at the same time) and deployment (poor planning in distributing and managing thousands of devices.)

The most significant problem for schools trying to go 1-to-1, though, has been a lack of educational vision. Without a clear picture of how teaching and learning is expected to change, experts say, going 1-to-1 often amounts to a "spray and pray" approach of distributing many devices and hoping for the best.

Some critics of educational technology also point to a recent study by the Organization for Economic Cooperation and Development, which found that countries where 15-year old students use computers most in the classroom scored the worst on international reading and math tests.

Additional resources:

- **Spotlight on 1-to-1 Computing**
- **Hard Lessons Learned in Ambitious L.A. iPad Initiative**
- **Chromebooks Gaining Popularity in School Districts**

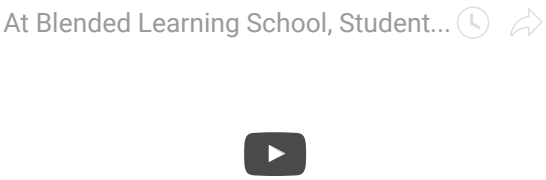
What Is Blended Learning?

In its simplest terms, blended learning combines traditional, teacher-to-student lessons with technology-based instruction.

Many schools and districts use a "rotation" model, which is often viewed as an effective means of providing students with more personalized instruction and smaller group experiences. In some cases, saving money (through larger overall class sizes, for example) is also a goal. The basic premise involves students rotating between online and in-person stations for different parts of the day. There are many versions of this approach, however: Do students stay in the classroom or go to a computer lab?

Does online instruction cover core content, or is it primarily for remediation? Are all students doing the same thing online, or do different students have different software and learning experiences?

One big trend for schools involves trying to make sure that what happens online is connected with what happens during face-to-face interactions with teachers. That could involve giving teachers a say in selecting the software that students use, for example, or making a concerted effort to ensure online programs provide teachers with data that is useful in making timely instructional decisions.



Step inside the San Francisco Flex Academy, which opened during the 2010-11 school year, and hear from students and educators who've

Another trend involves boosting students' access to the Internet outside of school. Robust blended learning

programs involve "anytime, anywhere" access to learning content for students—a major challenge in many communities.

embraced the school's blended-learning model. **View more ed-tech videos.**

Perhaps the biggest hurdle confronting educators interested in blended learning, though, is the lack of a solid research base. As of now, there is still no definitive evidence that blended learning works (or doesn't.) While some studies have found encouraging results with specific programs or under certain circumstances, the question of whether blended learning positively impacts student learning still has a mostly unsatisfactory answer: "It depends."

Additional resources:

- **Blended Learning: Breaking Down Barriers (*Education Week* special report)**
- **Blended Learning Research: The 7 Studies You Need to Know**
- **Spotlight on Blended Learning**

What Is the Status of Tech Infrastructure and the E-Rate?

The promise of technology in the classroom is almost entirely dependent on reliable infrastructure. But in many parts of the country, schools still struggle to get affordable access to high-speed Internet and/or robust wireless connectivity.

A typical school district network involves multiple components. In 2014, the Federal Communications Commission established connectivity targets for some of the pieces:

- A connection to the broader Internet provided by an outside service provider to the district office (or another central district hub).
  Target: 100 megabits per second per 1,000 students in the short-term, and 1 Gigabit per second per 1,000 students in the long-term.
- A "Wide Area Network" that provides network connections between the district's central hub and all of its campuses, office buildings, and other facilities.
  Target: Connections capable of delivering 10 Gigabits per second per 1,000 students.
- "Local Area Networks" that provide connections within a school, including the equipment necessary to provide Wi-Fi service inside classrooms.
  Target: The FCC recommended a survey to determine a suitable measure. Many school-technology advocates call for internal connections that support 1-to-1 computing.

To support schools (and libraries) in building and paying for these networks, the FCC in 1996 established a program known as the E-rate. Fees on consumers' phone bills fund the program, which has paid out more than $30 billion since its inception.

In 2014, the commission overhauled the E-rate, raising the program's annual spending cap from $2.4 billion to $3.9 billion and prioritizing support for broadband service and wireless networks. The changes were already being felt as of Fall 2015; after steadily declining for years, the number of schools and libraries applying for E-rate funds for wireless network equipment skyrocketed, with nearly all of the applicants expected to receive a portion of the $1.6 billion in overall wireless-related requests.

As part of the E-rate overhaul, the FCC also approved a series of regulatory changes aimed at leveling the playing field for rural and remote schools, which often face two big struggles: accessing the fiber-optic cables that experts say are essential to meeting the FCC's long-term goals, and finding affordable rates.

Infrastructure in some contexts can also be taken to include learning devices, digital content, and the policies and guidelines that govern how they are expected to be used in schools (such as "responsible use policies" and "digital citizenship" programs aimed to ensure that students and staff are using technology appropriately and in support of learning goals.)

High school students in Coral Gables, Fla., work together on a tablet during a history class.

—Josh Richie for Education Week

Another big—and often overlooked—aspect of infrastructure is what's known as interoperability. Essentially, the term refers to common standards and protocols for formatting and handling data so that information can be shared between software programs. A number of frameworks outline data interoperability standards for different purposes. Many hope to see the field settle on common standards in the coming years.

Additional Resources:

- **The Typical School Network (EducationSuperHighway)**
- **The E-rate Overhaul in 4 Easy Charts**
- **Reversing a Raw Deal: Rural Schools Still Struggle to Access Affordable High Speed Internet (*Education Week* special series)**

How Is Online Testing Evolving?

The biggest development on this front has been states' adoption of online exams aligned with the Common Core State Standards. During the 2014-15 school year, 10 states (plus the District of Columbia) used exams from the Partnership for Assessment of Readiness for College and Careers (PARCC), and 18 states used exams from the Smarter Balanced Assessment Consortium, all of which were delivered primarily online. Many of the other states also used online assessments.

The 2015-16 school year will be the first in which more state-required summative assessments in U.S. middle and elementary schools will be delivered via technology rather than paper and pencil, according to a recent analysis by EdTech Strategies, an educational technology consulting firm.

Beyond meeting legislative mandates, perceived benefits include cost savings, ease of administration and analysis, and the potential to employ complex performance tasks.

But some states—including Florida, Minnesota, Montana, and Wisconsin—have experienced big problems with online tests, ranging from cyber attacks to log-in problems to technical errors. And there is growing evidence that students who take the paper-and-pencil version of some

important tests perform better than peers who take the same exams online, at least in the short term.

Nevertheless, it appears likely that online testing will continue to grow—and not just for state summative assessments. The U.S. Department of Education, for example, is among those pushing for a greater use of technologically enhanced formative assessments that can be used to diagnose students' abilities in close to real time. In the department's 2016 National Education Technology Plan, for example, it calls for states and districts to "design, develop, and implement learning dashboards, response systems, and communication pathways that give students, educators, families, and other stakeholders timely and actionable feedback about student learning to improve achievement and instructional practices."

Additional Resources:

- **PARCC Scores Lower for Students Who Took Exams on Computers:**
- **Map: The National K-12 Testing Landscape**
- **Pencils Down: The Shift to Online and Computer-Based Testing (EdTech Strategies)**
- **Online Testing Glitches Causing Distrust in Technology**
- **U.S. Ed-Tech Plan Calls Attention to 'Digital-Use Divide'**

How Are Digital Materials Used in Classrooms?

Digital instructional content is the largest slice of the (non-hardware) K-12 educational technology market, with annual sales of more then $3 billion. That includes digital lessons in math, English/language arts, and science, as well as "specialty" subjects such as business and fine arts. The market is still dominated by giant publishers such as Houghton Mifflin Harcourt and Pearson, who have been scrambling to transition from their print-centric legacy products to more digital offerings.

But newcomers with one-off products or specific areas of expertise have made inroads, and some apps and online services have also gained huge traction inside of schools.

As a result, many schools use a mix of digital resources, touting potential benefits such as greater ability to personalize, higher engagement among students, enhanced ability to keep content updated and current, and greater interactivity and adaptivity (or responsiveness to individual learners).

Still, though, the transition to digital instructional materials is happening slowly, for reasons that range from the financial (for districts that haven't been able to purchase devices for all students, for example) to the technical (districts that lack the infrastructure to support every student being online together.) Print still accounts for about 70 percent of pre-K-12 instructional materials sales in the United States.

Additional Resources:

- **Spotlight on Using Digital Content**

- **Digital Content Providers Ride Wave of Rising Revenues**
- **K-12 Print Needs Persist Despite Digital Growth**

What Are Open Educational Resources?

Rather than buying digital instructional content, some states and districts prefer using "open" digital education resources that are licensed in such a way that they can be freely used, revised, and shared. The trend appears likely to accelerate: The U.S. Department of Education, for example, is now formally encouraging districts to move away from textbooks and towards greater adoption of OER.

New York and Utah have led the way in developing open educational resources and encouraging their use by schools. The K-12 OER Collaborative, which includes 12 states and several nonprofit organizations, is working to develop OER materials as well.

Seventh grader Mateo Smith, center, uses a laptop at Hughes STEM High School in Cincinnati.

—Pat McDonogh for Education Week

Proponents argue that OER offer greater bang for the buck, while also giving students better access to a wider array of digital materials and teachers more flexibility to customize instructional content for individual classrooms and students. Some also believe OER use encourages collaboration among teachers. Concerns from industry and others generally focus on the quality of open materials, as well as the challenges that educators face in sifting through voluminous one-off resources to find the right material for every lesson.

Additional Resources:

- **What is OER? (Creative Commons)**
- **Districts Put Open Educational Resources to Work**
- **Calculating the Return on Open Educational Resources**

How Are Virtual Education and Distance Learning Doing?

One technology trend that has come under increasing scrutiny involves full-time online schools, particularly cyber charters. About 200,000 students are enrolled in about 200 publicly funded, independently managed online charter schools across 26 states.

But such schools were found to have an "overwhelming negative impact" on student learning in a comprehensive set of studies released in 2015 by a group of research organizations, including Stanford University's Center for Research on Education Outcomes at Stanford University.

That research did not cover the more than two dozen full-time online schools that are state-run, however, nor did it cover the dozens more that are run by individual school districts. Thousands upon thousands of students who are enrolled in traditional brick-and-mortar schools also take individual courses online. Five states—Alabama, Arkansas, Florida, Michigan, and Virginia—now

require students to have some online learning to graduate. Other states, such as Utah, have passed laws encouraging such options for students.

For many students, especially those in rural and remote areas, online and distance learning can offer access to courses, subjects, and teachers they might otherwise never be able to find. Such opportunities can also benefit advanced and highly motivated students and those with unusual schedules and travel requirements, and be a useful tool to keep schools running during snow days.

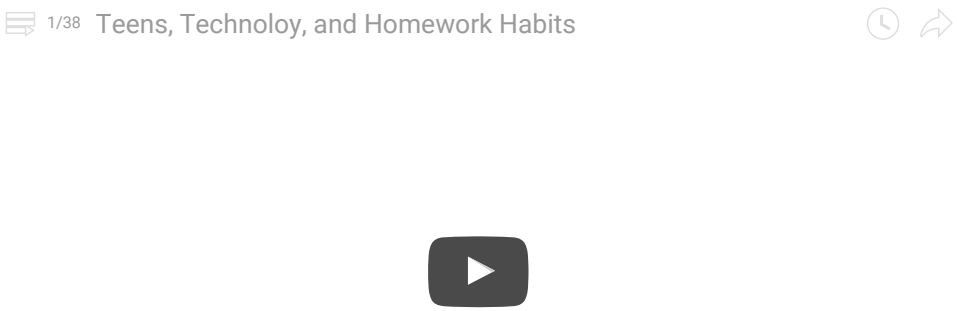
But so far, achieving positive academic outcomes at scale via online learning has proven difficult, and many observers have expressed concerns about the lack of accountability in the sector, especially as relates to for-profit managers of online options.

Additional Resources:

- **Spotlight on Implementing Online Learning**
- **Online Learning Options (National Conference of State Legislators)**
- **Cyber Charters Have 'Overwhelming Negative Impact'**

Video Playlist: Technology in Education

Browse *Education Week*'s collection of videos on ed-tech issues:



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