Chapter 1

Educational Technology in Context

THE BIG PICTURE

Learning Outcomes

After reading this chapter and completing the learning activities, you should be able to:

1.1 Analyze how (a) historical perspectives on educational technology, (b) current definitions for educational technology and integrating educational technology, and (c) educational technology resources in schools shape opportunities for integrating educational technology in classrooms. (ISTE Standards for Educators: 1—Learner; 5—Designer)

1.2 Describe how the history of digital technology shapes opportunities for integrating educational technology in classrooms. (ISTE Standards for Educators: 1—Learner; 5—Designer)

1.3 Understand technology literacy and other 21st-century learning standards that teachers implement for student learning and growth. (ISTE Standards for Educators: 1—Learner; 5—Designer; 6—Facilitator)

1.4 Articulate the impact of educational, political, technical, societal, equity/cultural, and legal/ethical conditions on current uses of technology in education. (ISTE Standards for Educators: 2—Leader; 3—Citizen; 4—Collaborator; 5—Designer)

1.5 Characterize trends in emerging technologies and describe how they shape teaching and learning. (ISTE Standards for Educators: 1—Learner; 2—Leader; 5—Designer)

Technology Integration In Action: Then and Now

Then . . . Ms. Thomas was almost as proud of her new classroom computers as she was of her new teaching degree. She had high hopes for the 1981–1982 school year in her first teaching position, especially because the principal had asked her whether she could use two brand-new Apple computer systems that had been donated to the school. As a student teacher, she had helped children use **computer-assisted instruction (CAI)** on terminals that were located in a school's computer lab and connected by telephone lines to her university's big mainframe computer, but this would be much different. These computers would be located right in her classroom, and she would have access to Success-Maker, a CAI software created by the Computer Curriculum Corporation. Students would build and practice their math and reading skills in 15–30 minute sessions across the day.

Ms. Thomas also found MECC software, such as Oregon Trail, and successfully lobbied the principal to buy it. With Oregon Trail, students were transported to 1848 as pioneers traveling from Missouri via wagons to resettle in Oregon. She also discovered Apple **Logo** with which students could engage in computer programming that controlled a turtle icon that moved and drew lines on the screen. All the students wanted to use the computers, but with only two machines, Ms. Thomas quickly managed the activities to allow everyone to have turns.

As Ms. Thomas used her new computers, she coped with a variety of technical problems. Sometimes the software would stall when students entered something the programmers had not anticipated; students would restart the programs and lose some work. Despite these and other difficulties, by the end of the year, Ms. Thomas was still enthusiastic about her hopes, plans, and expectations. She felt she had seen a glimpse of a time when computers would be an integral part of everyday teaching activities. She planned to be ready for the future.

Now . . . As Ms. Thomas begins another school year, she reflects on her first pioneering work with her Apple computers almost 40 years ago and the technology possibilities available now. She has an **interactive whiteboard,** a device that allows her to project information from a computer to a screen and then manipulate it either with special pens or hands. But this school year, she and all her students have received tablet computers as part of the school district's **one-to-one computing** initiative. The district offered these tools to any teachers who proposed innovative ways to engage all students in science, engineering, and math projects. With these devices, it would be so much easier for her students to access science simulations and online math manipulatives, support **makerspace** projects, and collaborate with learners and experts in other locations. She was excited for the **citizen science** project in which her students would collaborate with others around the state to gather and compare data on local environmental conditions.

Ms. Thomas also marvels at how most other teachers in the school use technology in productive ways. Teachers communicate via email or online chats, and many have their own, school-approved **social networking site (SNS)** for learning—Edmodo—so that students and parents can get up-to-date information on school and classroom activities and communicate with each other and the teacher. Students use **graphing calculators** to solve problems, and they use online programs to practice foreign languages. She often hears them talking about **virtual field trips** they took in science and social studies. A video project to interview war veterans has drawn a lot of local attention, and the student projects displayed on school digital displays are ablaze with websites and images students had taken with digital cameras.

There were still problems, of course. Computer **viruses** and **spam** sometimes slowed the district's network, and the **firewall** that had been put in place to prevent students from accessing undesirable websites also prevented access to many other perfectly good sites. Teachers reported intermittent problems with **cyberbullying** and inappropriate postings on social network sites despite the school's **acceptable use policies.** Some teachers complained that they had no time for innovative technology-based projects because they were too busy preparing students for the state tests that would determine students' progress, their school's rating, and their own effectiveness scores as teachers.

Despite these concerns, Ms. Thomas is amazed at how far educational technology has come from those first, exciting, exploratory steps she took back in 1981 and how much more there still is to examine. She knows other teachers her age who retired, but she's too interested in what she's doing to retire yet. She's helping with a virtual program for homebound students and leading a funded project to develop curricula for the district's social media. Not a day goes by that a teacher doesn't come to her for help with a new project. She can't wait to see what challenges lie ahead. She is looking forward to the future.

Introduction

Today's educators tend to think of educational or instructional technology as devices or equipment—particularly the more modern, digital devices, such as computers, mobile phones, and tablets. But educational technology is not new at all, and it is by no means limited to the use of devices. Modern tools and techniques are simply the latest developments in a field that is as old as education itself. This chapter begins our exploration of educational technology with an overview of the field from the historical perspectives that shape and define it to the resources and conditions that determine the role it plays in today's society and schools.

The "Big Picture" on Technology in Education

The big picture review in this section serves an important purpose: It helps learners develop mental pictures of the field, what Ausubel (1968) might call cognitive frameworks, through which you can view all technology and consider best courses of action. In this chapter, you will learn the big picture by doing the following:

- **Reviewing key terminology**—Talking about a topic requires knowing the vocabulary relevant to that topic. Language used to describe technology reflects differing perspectives on the use of educational technology.
- **Reflecting on the past**—Showing where the field began helps us understand where it is headed and why. Over time, changes in goals and methods in the field cast new light on the challenges and opportunities of today's technologies.
- **Considering the present**—Available technologies dictate possibilities, but a combination of political, educational, technical, social, cultural, and legal issues influences the current uses of educational technology.
- **Looking ahead to the future**—Technology resources and societal conditions change so rapidly that today's teachers must be futurists who critically analyze emerging trends.

Perspectives That Define Educational Technology

Saettler (1990) says that the earliest references to the term *educational technology* were made by radio instruction pioneer W. W. Charters in 1948, and *instructional technology* was first used by audiovisual expert James Finn in 1963. Even in those early days, definitions of these terms focused on more than just devices and materials. Saettler noted that the 1970 Commission on Instructional Technology defined educational technology as both (1) the media developed by communication technologies and (2) a system for designing, using, and evaluating the media used for teaching and learning purposes. As the 1970 commission concluded, a broader definition of educational technology that encompasses both resources and processes was important for the future.

If educational technology is viewed as both processes and resources, it is important to begin by examining five different historical perspectives on these processes and resources. All of them have helped shape current practices in the field. These influences come to us from five areas of education and society, each with a unique outlook on what technology in education is and should be. Some of these views have merged over time, but each retains a focus that tends to shape integration practices. These five views and the professional organizations that have represented them are summarized in Table 1.1.

PERSPECTIVE 1: EDUCATIONAL TECHNOLOGY AS COMMUNICATIONS MEDIA

This perspective grew out of the audiovisual (AV) movement in the 1930s when higher education instructors proposed that media such as slides and films delivered information in more concrete and therefore more effective ways than did lectures and books. This movement built upon educational research and practices focused on how to design and use messages optimally in audiovisual communications for teaching and learning. The view of educational technology as delivery media has dominated areas of education and the communications industry.

Table 1.1 Organizations with Various Perspectives on Technology in Education

Association for Educational Communications and Technology (AECT)	International Technology and Engineering Educators Association (ITEEA)	International Society for Performance Improvement (ISPI)	International Society for Technology in Education (ISTE)	International Society of Learning Sciences (ISLS)
Perspectives on Technology in Education				
Initial focus: Audiovisual (AV) devices and media *Now:* Use of technology resources to improve instruction	*Initial focus:* Manufacturing and materials skills *Now:* STEM education and careers	*Initial focus:* Information concerned with programmed instruction *Now:* Improvement of human performance	*Initial focus:* Computer systems *Now:* Improvement of teaching and learning with digital resources for global connectedness	*Initial focus:* Augmentation of learning with technologies *Now:* Multi-disciplinary, design-based technology learning innovations
Current Definitions for Technology in Education				
Educational technology facilitates efficient and effective learning and improves performance by using technologies	*Technology education* is problem-based learning using STEM principles	*Human performance technology* is a systematic approach to improve productivity and competence	*Educational technology* is the full range of digital resources used to support teaching and learning	*Educational technology* involves designing digital learning environments that motivate learners to think and know deeply in authentic contexts

PERSPECTIVE 2: EDUCATIONAL TECHNOLOGY AS INSTRUCTIONAL SYSTEMS AND INSTRUCTIONAL DESIGN This view originated with post-World War II military and industrial trainers who were faced with preparing large numbers of personnel quickly. Based on efficiency studies and learning theories from educational psychology, these trainers advocated using more planned, systematic approaches to developing uniform, effective materials and training procedures. Their view was based on the belief that both human (teachers) and nonhuman (media) resources could be part of an efficient system for addressing any instructional need. Therefore, they equated "educational technology" with "educational problem solutions." This perspective has evolved into **human performance technology**, a systematic approach to improving human productivity and competence by using strategies for solving problems.

PERSPECTIVE 3: EDUCATIONAL TECHNOLOGY AS VOCATIONAL TRAINING Also known as **technology education**, this perspective originated with industry trainers and vocational educators in the 1980s. They believed that (1) an important function of school learning is to prepare students for the world of work in which they will use technology and (2) vocational training can incorporate practical means of teaching all content areas, such as math, science, and language. This view brought about a major paradigm shift in vocational training in K–12 schools away from industrial arts curricula centered in woodworking/metals and graphics/printing shops toward technology education courses taught in labs equipped with technology stations such as graphics production, robotics systems, and **computer-aided design (CAD)** software, a program used by architects and others to aid in the design of structures such as houses and cars.

PERSPECTIVE 4: EDUCATIONAL TECHNOLOGY AS COMPUTER SYSTEMS (A.K.A. EDUCATIONAL AND INSTRUCTIONAL COMPUTING) This view began in the 1950s with the advent of computers and gained momentum when they began to be used instructionally in the 1960s. As computers began to transform business and industry practices, both trainers and teachers began to see that computers also had the potential to aid instruction. From the time computers came into classrooms in the 1960s until about 1990, this perspective was known as educational computing and encompassed both instructional and administrative support applications.

At first, programmers and systems analysts created all applications. But by the 1970s, many educators involved with media, AV communications, and instructional systems also were researching and developing computer applications. By the 1990s, educators began to see computers as part of a combination of technology resources, including media, instructional systems, and computer-based support systems. At that point, educational computing became known as **educational technology**.

PERSPECTIVE 5: EDUCATIONAL TECHNOLOGY AS LEARNING SCIENCES In 1970s and 1980s, new understandings about how people learn influenced the emergence of the **learning sciences** in the early 1990s. Researchers found that knowledge was more than recalling facts but also included developing skills and deep conceptual knowledge, which can be learned and represented differently by individuals. Learning processes involved building instruction around what learners already knew with relevant and authentic topics that are meaningful to learners and provided scaffolding, which is assistance from experts that can include peer learners, technological guidance, and teachers. Researchers acknowledged that learning can occur individually or with others and is influenced by the context in which it occurs (e.g., in a math classroom, during after school playtime) and by culture.

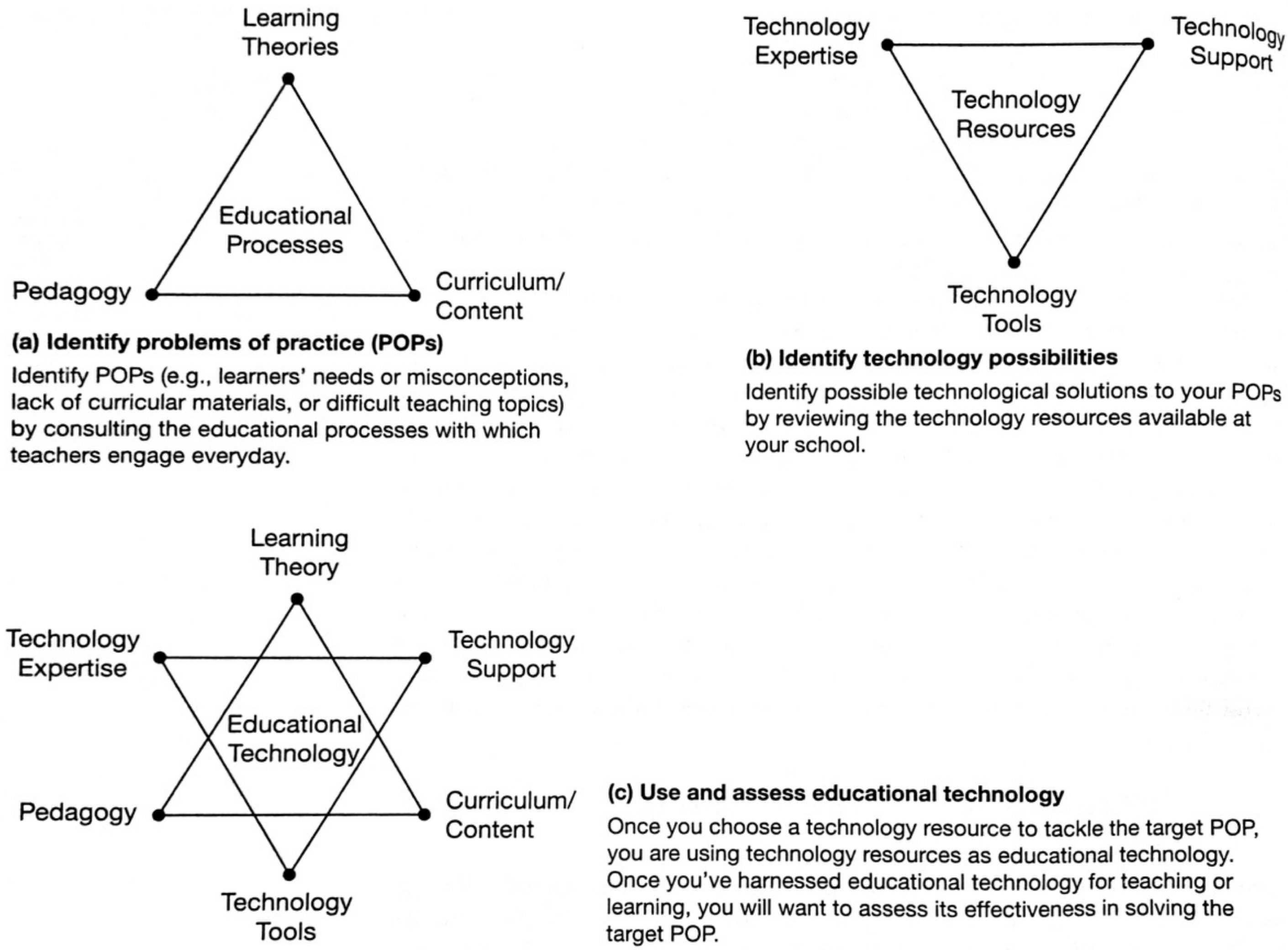
Working from these understandings, learning scientists tend to be interventionists who build technology-based learning environments that anchor curricular content within authentic, real, and simulated problems with a goal to transform teaching and learning. For example, students learned persuasive writing by becoming a protagonist and avatar in a videogame called *Plague: Modern Prometheus*. They collected evidence within the videogame environment and wrote letters to convince in-game characters of their position on specific approaches to curing the plague (Barab, Pettyjohn, Gresalfi, Volk, & Solomou, 2012). Learning science is very multidisciplinary, often involving ideas from psychology, sociology, anthropology, linguistics, and computer science. Learning scientists, often working in teams including practitioners such as teachers, conduct **design-based research** to investigate how people think and know, how learning processes function, and how to design learning environments to support learning. This research is done in applied contexts, such as schools or libraries, and repeated many times as the researchers use their research to improve and re-examine subsequent redesigned interventions.

How This Textbook Defines Integrating Educational Technology

Each of these five perspectives on technology in education has contributed to the current body of knowledge about processes and resources to address educational needs. Because an informed use of educational technology must focus on all of these perspectives, this textbook attempts to merge them in the following ways:

- **Educational processes** include a set of three knowledge areas through which to consider the role of technological resources, including (1) learning theories based on the sciences of human behavior, (2) pedagogical or instructional practices that complement learning theories, and (3) curriculum standards or content knowledge that inform our learning objectives or goals.
- **Technology resources** in this textbook are viewed as technology tools (e.g., media, software, and hardware) and technology support and expertise. We choose the term **resource** to capture the idea that there exists a generous supply of technological tools, support, or expertise available that can be accessed and used when needed. A technology **tool** is a device such as a **clicker** or software application such as a word processor or Twitter that accomplishes a specific task.
- **Educational technology** refers to *resources* leveraged to support the educational *processes* involved in teaching and learning.
- **Integrating educational technology** refers to an individual or collaborative process of (1) identifying **problems of practice (POPs)** (e.g., learners' needs or misconceptions, lack of curricular materials, difficult teaching topics), (2) identifying technological resources as possible solutions, (3) using the resources as educational technology in the learning environment, and (4) assessing whether the educational technology solves the target POP in ways that replace, amplify, or transform teaching and learning.

Figure 1.1 A Framework for Integrating Educational Technology



(a) Identify problems of practice (POPs)
Identify POPs (e.g., learners' needs or misconceptions, lack of curricular materials, or difficult teaching topics) by consulting the educational processes with which teachers engage everyday.

(b) Identify technology possibilities
Identify possible technological solutions to your POPs by reviewing the technology resources available at your school.

(c) Use and assess educational technology
Once you choose a technology resource to tackle the target POP, you are using technology resources as educational technology. Once you've harnessed educational technology for teaching or learning, you will want to assess its effectiveness in solving the target POP.

Figure 1.1 visualizes the processes and resources in a framework for integrating educational technology.

An Overview of Technology Resources

Technology integration strategies require a combination of **hardware**, or computing equipment such as computers, and **software**, programs or applications (apps) written to perform various functions. Even today's **mobile devices**—portable, handheld computer equipment, such as cell phones or tablets—have this hardware/software combination. Sometimes software and data must be stored outside of the hardware using flash drives, hard drives, CDs, or various types of DVDs. These are thought of as **storage media** rather than hardware.

Online storage, referred to as **cloud computing**, is a generic term for using a storage service accessed through the Internet. Sometimes this service is fee based, and sometimes sites such as Google make it available as a free service. The latter is referred to as Google Drive, although it is not really a hard drive device in the traditional sense. Users can upload documents to storage either as a backup copy or as an alternate to storing items on one's own computer hard drive.

In addition to hardware and software digital tools, technology integration requires support and expertise beyond the classroom teacher. For example, technicians can provide support for broken technology. Librarians and technology specialists in your school might provide ideas and expertise for using technologies. Principals might provide special funding for projects you develop.

Hardware Setup for Classrooms

Seven types of technology hardware are commonly used in today's classrooms. These include:

1. **Network**—While often invisible in the classroom, your school most likely has a wired or wireless network that provides computing devices with access to the Internet. Computers can connect to a wired outlet in a wall using a cable, or they can be connected wirelessly via the computer's Wi-Fi settings. Networks can vary in signal strength and speed.
2. **Computers**—Computers, sometimes referred to as desktop or laptop computers, are options for classroom computing. Computers can also serve as network servers, which send out information to others on the Internet, commonly run by district staff for schools or classrooms.
3. **Handheld technologies**—Small devices, such as cell phones, tablets (e.g., iPads, Windows, Android tablets, Chromebooks), e-books or e-text readers (e.g., kindle, nook, kobo), calculators, and smartpens (e.g., Livescribe, Sky), offer mobile computing for teaching and learning. The devices' computing power and capabilities vary.
4. **Display technologies**—These devices support whole-class or large-group demonstrations of information from a computer. You can display computer and handheld technologies in your classroom on a television screen using a cable or remote connection with an Apple TV, on a digital projector often mounted on a ceiling, or on an **interactive whiteboard** (e.g., SMART Board, Promethean) that can be mobile or secured to a wall. Some of these displays can be used with devices such as **clickers** (a.k.a. **student response systems (SRS)**), which are wireless devices used for interactively polling student answers to teacher questions in face-to-face classes.
5. **Imaging technologies**—To make teaching and learning more visual, you might have access to digital cameras, video cameras, scanners, or **head-mounted displays (HMD)** (e.g., Google Cardboard or Oculus Rift) that allow the development and use of images ranging from still photos to full-motion videos and virtual reality.
6. **Peripherals**—These are the input devices to get information and requests into the computer for processing, such as a keyboard, mouse, stylus, scanner, and microphone. Output devices interpret the computer's information into visual or auditory formats, such as printers, synthesizers, and earphones. Peripherals make computers even more functional for a range of user needs.
7. **External storage device**—Computers store data, including applications and documents inside the computer on a hard drive and can access data stored on **storage media** (e.g., flash drive). Sometimes an external storage device such as an external hard drive is needed to hold large files, such as video recordings, that won't fit easily on storage media or inside the computer.

Software Applications in Schools

Schools carry out many types of activities in addition to teaching, and software has been designed to support each of these. Application (app) software refers to any program specifically designed to run on mobile devices such as smartphones and tablets. Apps are often designed exclusively for a given platform (e.g., Apple, Android). Universal apps are programs that work on all platforms. "There's an app for that" has quickly become a catchphrase as people have become dependent on their handheld devices to go online. The types of educational technology software and apps in school settings include:

- **Productivity**—Software designed to help teachers and students plan, develop materials, communicate, collaborate, and keep records. These include word processing, spreadsheet, database, and email programs as well as a variety of other materials generators and data collection/analysis, graphics, and research and reference tools. These programs do not have curricular material built into them.
- **Instructional**—Software designed to teach skills or information through demonstrations, examples, explanations, and problem solving. Functions of this software include drill and practice, tutorials, simulations, games, and problem-based and personalized learning. These programs include sequenced curricular material built into them.
- **Administrative**—Software that administrators, teachers, students, and parents use to support record keeping and information exchange. These include student records, such as grades, attendance, individualized education plans, and other private data. Sometimes schools use **student information software (SIS)** to maintain this information.

Technology integration strategies described in this textbook focus primarily on productivity and instructional applications that teachers and students use. However, some administrative applications are also described.

Technology Support and Expertise

Classroom teachers likely need support and expertise from others when integrating technology. Such support and expertise can be sought through:

- **Technology specialists**—These support staff typically focus on working individually with teachers to identify ideas and ways to use the available technology hardware and software tools in the classroom. Sometimes these specialists or other instructional technology (IT) staff are responsible for fixing technical issues, such as dead computers, jammed printers, or software installation.
- **Leaders**—It is helpful to meet the IT director for your district who might oversee technology purchasing, distribution, and professional learning opportunities. School and district librarians are expanding their role as technology leaders; many have begun makerspaces in their libraries, and they thrive on collaborations with teachers. Your school principal or assistant principal is involved in setting policies and could have access to funding.
- **Parents and students**—Parents might be interested in volunteering to assist with technology-related projects, or they could have specialized industry knowledge that could be an asset for the school. Students can possess a great deal of experience with current recreational technologies. Teachers can learn from and be supported by students in their own classrooms.
- **Technology policies**—Teachers should investigate the existing policies involving technologies at their school, which could include **acceptable use policy (AUP), website and intranet policy, student use of personal electronic device policy,** and **bullying prevention policy**. It is important for teachers to understand the expectations for students' technology use and that their own technology-related behavior is also governed by school and district policies.
- **Technology procedures**—School districts and individual schools and their staff likely have procedures related to access to and use of technologies, such as the frequency each teacher can check out and use a computer lab or set of laptops. Colleagues can also share valuable strategies for classroom management of technology specific to your school.

✓ **Check your Understanding 1.1**

Shared Writing 1.1 Understanding Technology Resources in Your School

Educational Technology: How the Past Shapes the Present and Future

Although technology can be anything from a pencil to a virtual environment, the modern history of technology in education has been shaped in large part by developments in digital technologies including computers. The five eras in the history of digital technologies, shown in Figure 1.2, are described in this section, followed by a summary of what we have learned from the past that can help us become more effective technology users today.

Figure 1.2 Digital Technologies in Education: A Timeline of Events That Shaped the Field

Mainframe Computer Era

- **1950** **First computers are used for instruction** Computer-driven flight simulator trains MIT pilots
- **1959** **First computer is used with school children** IBM 650 teaches binary arithmetic in New York City
- **1960s** **University time-sharing movement begins** Mainframes are used for programming and shared utilities
- **Early 1970s** **Computer-assisted instruction (CAI) movement begins** Schools use university-based mainframes/ mini-computers
- **Mid-to-late 1970s** **Schools begin using computers for instruction and administration** CDC announces PLATO system
- **Late 1970s** **Arthur Luehrmann coins term *computer literacy*** Andrew Molnar warns non-computer-literate students are a risk

Microcomputer Era

- **1977** **Microcomputers enter schools** Teachers begin to control instructional applications
- **1980s** **Microcomputer movements begin** Software publishing, teacher authoring, LOGO problem solving get underway
- **1980s–early 1990s** **Movement to networks begins** ILS marks a shift to networks and away from desktop computers

Internet Era

- **1993** **World Wide Web is born** First browser (Mosaic) transforms Internet, and teachers enter information superhighway
- **1994** **Internet use explodes** Distance learning increases in higher education
- **1995** **Virtual schooling begins** Online course offerings begin in high schools

Mobile Technologies, Social Media, and Open Access Era

- **2001** **Wikipedia begins** Crowdsourcing movement gains momentum
- **2005** **Social networking begins** Facebook is invented
- **2006** **Twitter is invented** Social media enters classrooms
- **2007** **Books go digital and mobile** Amazon releases first Kindle e-book reader
- **2008** **First MOOC is taught** Stephen Downes and George Siemens opened their university course to all for free
- **2010** **Mobile tablets become available** Apple releases first iPad tablet computer

Mobile Technologies, Social Media, and Open Access Era

- **2012** **Mobile technologies spawn BYOD/BYOT movements** The NMC K-12 Horizon Report foresees mobiles being used for BYOD in schools within 1 year or less
- **2013** **MOOC startups begin** Udacity, Coursera, and EdX startups are established
- **2016** **MIT celebrates 15th anniversary of its OpenCourseWare initiative** MIT has more than 2,200 free courses available to support knowledge sharing

Personalized, Adaptive Learning Era

- **2008** **Adaptive learning engine emerges** Knewton adaptive learning platform is founded
- **2009** **USDOE emphasizes data systems** "Race to the Top" program funded systemic change involving data innovations to support student growth and instruction
- **2016** **Facebook's Zuckerberg joins education efforts** Chan Zuckerberg Education Initiative to build personalized learning technologies is announced

Era 1: The Mainframe Computer Era

The first computers were used instructionally as early as the 1950s. In the late 1960s, IBM pioneered the IBM 1500, the first instructional **mainframe**, or large-scale computer with many users connected to it via terminals. Some mainframes filled large rooms. On the IBM 1500, these terminals were **multimedia learning stations** capable of displaying animation and video. By the time IBM discontinued it in 1975, some 25 universities were using this system to develop **computer-assisted instruction (CAI)** materials that schools used via long-distance connections to the mainframe. CAI was instructional software designed to help teach information and/or skills related to a topic.

The most prominent of these efforts was led by Stanford University professor and "Grandfather of CAI," Patrick Suppes, who developed the Coursewriter programming language to create reading and mathematics lessons. Companies such as the Computer Curriculum Corporation (CCC) founded by Suppes and the Programmed Logic for Automatic Teaching Operations (PLATO) system (developed by Control Data Corporation) dominated the field for about 15 years. Universities also developed CAI for these large-scale computers as well as **computer-managed instruction (CMI)** applications, the programs that kept track of students' performance data based on mastery learning models. Even after smaller **minicomputer** systems, then designated as systems smaller than mainframes that could support fewer users at a time, replaced mainframes to deliver CAI and CMI to schools, systems were expensive to buy and complex to operate and maintain, so school district offices controlled their purchase and use. But by the late 1970s, it was apparent that there was little support for computer-based curriculum controlled by district data processing and industry personnel; schools began to reject the business office model of using computers to revolutionize instruction.

Era 2: The Microcomputer Era

Integrated circuits made computers both smaller and more portable beginning in 1975, and teachers began to bring small, stand-alone, desktop computers called **microcomputers**, or systems designed for use by only one person at a time, into their classrooms. Now we refer to them as **computers**. This grassroots movement wrested control of educational computers from companies, universities, and school districts and placed them directly into the hands of teachers and schools. Several initiatives emerged to shape this new teacher-centered control: a software publishing movement that catered to teachers quickly sprang up; organizations emerged to review software and help teachers select quality products; and professional organizations, journals, and magazines began to publish software reviews and recommend "top products." Teachers clamored for more input into courseware design, so companies created authoring languages and systems (e.g., PILOT, SuperPILOT, GENIS, PASS). However, teacher authoring soon proved too time consuming, and interest faded. As schools searched for a way to make CAI more cost effective, districts began to purchase networked **integrated learning systems (ILSs)**. They provided both CAI-based curriculum and CMI functions to help teachers address required standards. Control of instructional computer resources moved again to central servers in school district offices. Three other technology initiatives also became prominent in this era:

1. **The computer literacy movement**—When author and researcher Arthur Luehrmann coined the term **computer literacy** to mean the required level of skills in using the computer, schools tried to implement computer literacy curriculum. However, these efforts were eventually dropped because of difficulties in defining and measuring skills.
2. **Videodisc-based curriculum**—Companies such as ABC News and Optical Data Corporation joined forces to offer curriculum on videodiscs for playback on

stand-alone videodisc players or microcomputers. But when other forms of optical and digital storage replaced videodisc technology, curricula were not transferred.

3. **The Logo movement**—A final focus during this period was on **Logo**, a high-level programming language originally designed as an **artificial intelligence (AI)** tool to emulate decision-making capabilities of the human mind. However, Seymour Papert (1980) used it to support his view that computers should be used as an aid to teach problem solving. Logo began to replace CAI as the "best use" of computer technology. Despite its popularity and the research showing that it could be useful in some contexts, researchers could identify no impact from Logo on mathematics and other curriculum skills, and interest in it had waned by the beginning of the 1990s.

Era 3: The Internet Era

By the beginning of the 1990s, the **Internet**, a worldwide collection of university computer networks that could exchange information by using a common software standard, had already been operating for many years. Then in 1993, the **World Wide Web (WWW)** was introduced. This was a system within the Internet that allowed graphic displays of websites through hypertext links, pieces of texts or images that allowed users to jump to other locations connected by the links. The first **browser** software (*Mosaic*) was designed especially to allow users to use these links, marking the beginning of the third era of educational technology. Teachers and students joined the throng of users on the "information superhighway," as it was called, and interest in computer technology's potential for instruction once again sprang to life. By the beginning of the 2000s, email, online (i.e., web-based) multimedia, and videoconferencing became standard tools of web users. Websites became a primary form of communication for educators, and distance education became a more prominent part of instructional delivery at all levels of education. The meaning of "online" changed from simply being on the computer to being connected to the web. **Virtual schools**, which facilitate learning when K–12 students and teachers are physically separated and instruction is synchronous or asynchronous, began a steady growth that has endured in public, charter, and private education.

Video Example 1.1 Advice for Virtual School Teachers and Students

In this video, students give advice for teachers and students who might want to teach in a virtual school.

Era 4: The Mobile Technologies, Social Media, and Open Access Era

This era began in the early 2000s when portable devices such as smartphones and tablets made Internet access and computer power more ubiquitous. As more and more individuals made texting and social networking sites, such as Facebook, Twitter, and Instagram, part of their everyday lives, this constant connectedness transformed educational practice. The ease of access to online resources and communications drove several movements.

- **Distance learning**—A dramatic increase in the number and type of distance learning offerings came about first in higher education and then in K–12 schools.
- **Electronic books (e-books** or **e-texts)**—Texts in digital form on computers, e-book readers, and cell phones became increasingly popular alternatives to printed texts. Some school districts eschewed book adoptions in favor of allowing educators to choose their digital materials.
- **Open access**—In 2000, Massachusetts Institute of Technology (MIT) faculty started a bold initiative to gather all course materials for the school's curriculum and make them freely available online. The initiative, **OpenCourseWare (OCW)**, launched in 2001 and still draws millions of visits by educators, students, and self-learners each month. Around 2008, open-access university offerings called **Massive Open Online Courses (MOOCs)** became available. They allowed anyone anywhere in the world to participate in college courses for free. By 2011, MOOC projects at MIT, Harvard, and Stanford popularized the concept, and MOOCs came into common use in other colleges, universities, and several start-up companies. Some MOOCs that held proprietary content or were fee-based were not truly "**open**," which means that anyone can join and participate for free and modify, remix, and reuse the content with appropriate attribution and without fees for others' use.
- **Mobile access**—One-to-one laptop programs (and later tablet programs) as well as **Bring Your Own Device (or Technology, BYOD or BYOT) programs** allowed students to use their own handheld devices for learning activities and accelerated the move to bring computer and Internet access into all classrooms.

As ubiquitous communications and social networking defined social practices in modern life, educators struggled to create appropriate policies and uses that could take advantage of this new power while minimizing its risks and problems.

Era 5: The Personalized, Adaptive Learning Era

Recent advancements in technology capabilities have led to a resurgence in developing personalized, adaptive learning enabled through technology. Personalized instruction is tailored to varying learning goals and content, instructional approaches, and pacing to match learners' needs and interests.

With more access to technologies, more learners are using a myriad of online or digital learning resources. Information about how learners use these resources can be collected, stored, and analyzed. Often the learner data generated are referred to as **big data** because these environments can record every click of a mouse; thus, the amount of collected data can be immense. **Learning analytics** are analysis techniques performed on educationally relevant big data to identify patterns in learning that inform or optimize assessment, instruction, learning, and design of digital learning resources. From this, innovators are building new instructional and administrative platforms that use **machine learning**, a type of artificial intelligence, to predict and anticipate the content and instruction needed to support learners' progress. Harnessing this power makes software adaptive because as the learner engages in activities, the software offers a range of options to meet the learner's predicted needs. For example, Knewton is an adaptive learning platform that can be incorporated into new software and digital content products to collect big data, analyze learning, and predict and offer learning pathways. Much of the current adaptive innovations being built are similar to yet more powerful than CAI and CMI were during Era 1. These current technical advancements are driving several educational innovations.

ADAPTIVE LEARNING TECHNOLOGIES Software and online environments adapt to learners' needs through sophisticated analysis of learner behaviors and interactions with resources or content. This software will adapt immediately by changing content, activities, and assessments for the learner. Most textbook publishers and app developers are building adaptive technology into their new products. For example, Dreambox Learning is an adaptive math software with game-based elements. In many cases, a data dashboard is available for the teacher and school leaders and sometimes for the learner and parent. Teachers can use the dashboard to examine individual student progress and provide further interventions as needed. School leaders can use dashboards to discover needs across groups of students (e.g., English learners, students in special education, those in racial minorities, and those in poverty).

PERSONALIZED LEARNING Whereas personalized instruction can be achieved without technology, current emphasis on it capitalizes on technology's affordances for varied instruction, assessment, and learning artifacts as well as for collection and analysis of student data. Optimally, characteristics of personalized instruction include (1) an academic learner profile, (2) learner-controlled learning path(s) with goals, (3) frequent formative assessment and progression determined by learner competency, and (4) robust teacher- and school-based supports. The U.S. Department of Education (USDOE) and organizations such as the Bill and Melinda Gates Foundation have special projects to increase personalized learning in PK–12 schools.

FORMATIVE ASSESSMENT Technology-based assessment is transforming ways that students and teachers understand learning achievement. Technology learning products now embed universally designed assessment that maintains accessibility for all students, is well aligned to the content standards, and expands the types of content-related questions from multiple choice to problem-based, simulation decision making or real-world performance, which can gauge complex cognition. Feedback within these learning products is immediate, facilitating instantaneous adaptations within the learning product, teacher oversight of progress and intervention, and learner self-monitoring.

COMPETENCY-BASED EDUCATION A movement away from gauging learning by counting students' time sitting in a classroom has led to a model focused on gauging learning by mastery of content knowledge and skills when learners demonstrate competency. This competency model allows more flexibility in the time, place, content, and pace of learning, leading particularly to expansion of online and blended learning, opportunities that allow learning via some combination of online and some face-to-face experiences, as well as inclusion in personalized learning models.

Some worry that the vast data collected about learners might be harmful (Shulman, 2016). Concerns have arisen regarding ownership, control, access, use, security, and privacy of the data. Most conservative views argue that the student (and parents and guardians of those under 18) must retain ownership and control over collected data and its use. Schools and districts adopting such innovations must plan for access, security, privacy, and use of this data, which is protected under the **Family Educational Rights and Privacy Act (FERPA)**.

What We Have Learned from the Past

In no small part, developments in digital technologies have shaped the history of educational technology. However, knowing the history of educational technology is useful only if we apply what we know about the past to future decisions and actions. What have we learned from more than 60 years of applying technology to educational problems that can improve our strategies now? The following points are among the most important.

NO TECHNOLOGY IS A PANACEA FOR EDUCATION Great expectations for products such as Logo, online MOOCs, and adaptive technologies have taught us that even the most current, capable technology resources offer no quick, easy, or universal solutions. Computer-based materials and strategies are usually tools in a larger system and must be integrated carefully with other resources and teacher activities. Planning to integrate educational technology must always begin with this question: What specific needs do my students and I have that (any given resource) can help meet?

TEACHERS USUALLY DO NOT DEVELOP TECHNOLOGY MATERIALS OR CURRICULUM In the microcomputer era, companies tried to market authoring systems so teachers could create their own materials, but such systems were never widely adopted. Teaching is one of the most time- and labor-intensive jobs in our society. With so many demands on their time, most teachers cannot be expected to develop software or create complex technology-based teaching materials. Publishers, school or district developers, and personnel in funded projects have traditionally provided the majority of this assistance; this seems unlikely to change in the future even for distance education courses or digital instructional materials.

"TECHNICALLY POSSIBLE" DOES NOT EQUAL "DESIRABLE, FEASIBLE, OR INEVITABLE" A popular saying is that today's technology is yesterday's science fiction. But science fiction shows us that technology can bring undesirable—as well as desirable—changes. For example, increased access to cell phones and tablets in classrooms means that online communication and information are increasingly available. But communication always comes with caveats, and readily available information is not always reliable or helpful. New technological horizons make it clear that it is time to analyze carefully the implications of each implementation decision. Better technology demands that we become critical consumers of its power and capability. We are responsible for deciding just which science fiction becomes reality.

TECHNOLOGIES CHANGE FASTER THAN TEACHERS CAN KEEP UP The history of educational technology has shown that resources and accepted methods of applying them will change, often quickly and dramatically. The need to continue learning new resources and to change instructional methods places a special burden on already overworked teachers. Gone are the days—if, indeed, they ever existed—when a teacher could rely on the same handouts, homework, or lecture notes from year to year. Educators might not be able to predict the future of educational technology, but they know that it will be different than it is in the present; that is, they must anticipate and accept the inevitability of change and the need for a continual investment of their time.

OLDER TECHNOLOGIES CAN BE USEFUL Technology in education is an area especially susceptible to fads. With so little time and resources dedicated to identifying what actually works, anyone can propose dramatic improvements. When they fail to appear, educators move to the next fad. This approach fails to solve real problems, and it draws attention away from the effort to find legitimate solutions. Worse, teachers sometimes throw out methods that had potential but were subject to unrealistic expectations. The past has shown that teachers must be careful, analytical consumers of technological innovation, looking to what has worked in the past to guide their decisions and measure their expectations in the present. Educational practice tends to move in cycles, and "new" methods often are old methods in new guise. In short, teachers must be as informed and analytical as they want their students to become.

TEACHERS ALWAYS WILL BE MORE IMPORTANT THAN TECHNOLOGY The developers of the first instructional computer systems in the 1960s foresaw them replacing many teacher positions; some advocates of today's distance learning methods envision a similar impact on future education. Yet good teachers are more essential now than ever. One reason for this was described in Naisbitt's (1984) *MegaTrends*: "whenever new technology is introduced into society, there must be a counterbalancing human response . . . the more high tech [it is], the more high touch [is needed]" (p. 35). We need more teachers who understand the role that technology plays in society and in education, who are prepared to take advantage of its power, and who recognize its limitations. In an increasingly technological society, we need more teachers who are both technology savvy and child centered.

✓ **Check Your Understanding** 1.2

Today's Educational Technology Standards and Teaching Competencies

Clearly, 21st-century educators will have to deal with issues and situations that their predecessors could not even have imagined. New technology resources also mean new and different ways of accessing and processing information needed for teaching and learning. Both teachers and students must have the skills and knowledge that will prepare them to meet these new challenges and use these new and powerful strategies. Next we review content and technology standards for students and teachers and conceptual frameworks that assist teachers in integrating technology into the classroom.

The Common Core State Standards (CCSS) and Content Standards

The **Common Core State Standards (CCSS)** are grade-level standards stating the knowledge and skills that K–12 students should learn in mathematics and English language arts (ELA) and literacy. They were developed by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO). Some states do not use the CCSS, so teachers need to understand what student standards guide teaching in those states. The CCSS ELA standards mention using digital media, "nonprint" texts, assistive technologies, online searching, collaboration, and publishing. The CCSS mathematics standards predominantly frame technology for understanding and visualizing math concepts, particularly graphs and statistics. For more guidance on technology's role in helping students develop content knowledge, teachers should examine content-area standards such as the Next Generation Science Standards, National Curriculum Standards for Social Studies, Standards for the English language arts by National Council of Teachers of English and the International Literacy Association, Principles and Standards for School Mathematics by the National Council of Teachers of Mathematics, National Standards for Art Education, National Standards for Learning Languages, and SHAPE America's National Standards for Physical Education.

ISTE Standards for Students and Educators

Although the CCSS and content standards include some framing for students' technological knowledge and skills, the International Society for Technology in Education (ISTE), a professional organization described earlier in this chapter, has developed standards specifically about technology in education. The 2016 ISTE Standards for Students (ISTE, 2016) are considered a framework to be used with other standards to amplify or transform learning. The seven student standards emphasize learners as (1) empowered learners, (2) digital citizens, (3) knowledge constructors, (4) innovative designers,

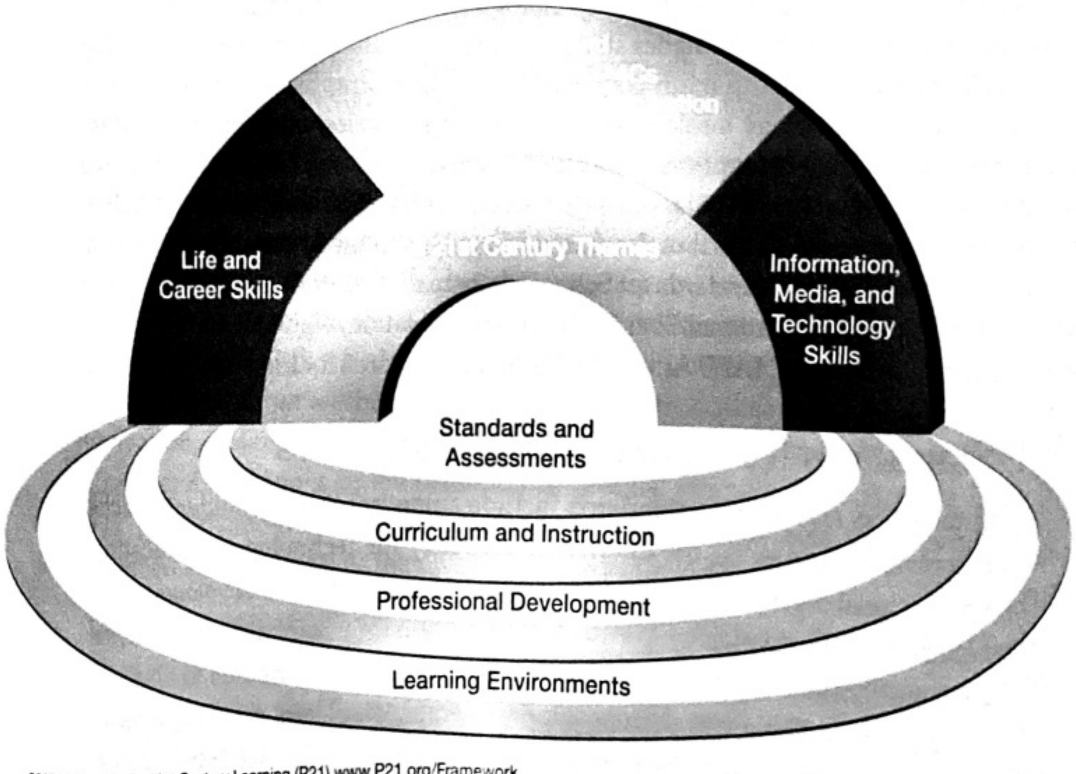
(5) computational thinkers, (6) creative communicators, and (7) global collaborators. All Technology Integration Examples in this book address these standards for students. The 2017 ISTE Standards for Educators (ISTE, 2017) outline the knowledge, skills, dispositions, and actions that educators need to effectively support students to meet these ISTE standards. The seven educator standards position an educator as an empowered professional and learning catalyst who is a (1) learner, (2) leader, (3) citizen, (4) collaborator, (5) designer, (6) facilitator, and (7) analyst. The learning objectives in each chapter in this book meet the ISTE Standards for Educators. This organization also has standards for administrators, technology coaches, and computer science educators.

THE PARTNERSHIP FOR 21ST-CENTURY LEARNING FRAMEWORK The Partnership for 21st-Century Learning Framework (P21) advocates the importance of all students developing 21st-century skills to ensure success in college and careers. The P21 framework for 21st-century learning identifies four interconnected areas of student outcomes that contribute to preparing a 21st-century learner. These outcomes include *academic content knowledge*, such as English language arts, mathematics and other subject areas, and *interdisciplinary perspectives*, such as global awareness; financial, economic, business, and entrepreneurial literacy; civic literacy; health literacy; and environmental literacy. The second outcome is the development of *learning and innovation skills*, such as creativity, critical thinking, communication, and collaboration skills, a set that is often referred to as the 4Cs. The third set of outcomes includes *information, media, and technology skills*, such as literacies to evaluate, use and manage information; analyze and create media; and apply technology effectively. The final outcomes include *life and career skills*, such as flexibility, initiative, social and cross-cultural skills, and leadership. These four-interrelated sets of student outcomes can be achieved only through support structures, including standards, assessment, curriculum, instruction, professional learning, and learning environments that are aligned with the 21st-century vision as depicted in Figure 1.3.

The ICT Competency Framework for Teachers

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) personnel collaborated with industry partners Cisco, Intel, ISTE, and Microsoft to create the Information and Communication Technology Framework for Teachers (ICT-CFT). This

Figure 1.3 The P21 Skill Framework for 21st Century Learning



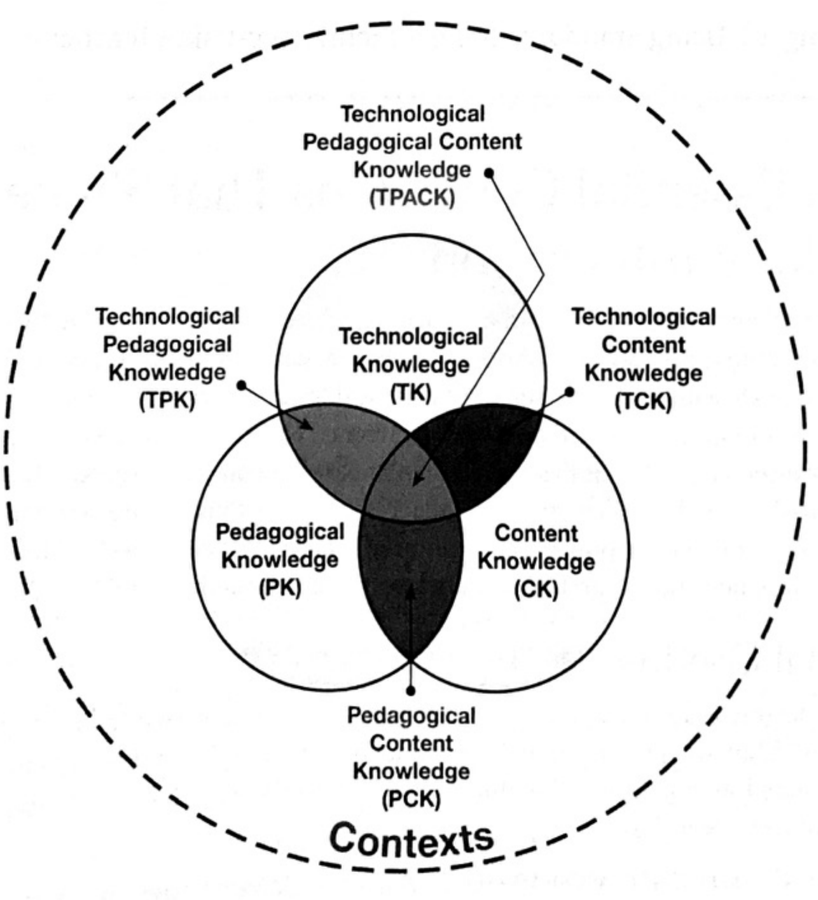
2007 Partnership for 21st Century Learning (P21) www.P21.org/Framework

framework focuses on skills that teachers require to bring about three different levels of human capacity development: technology literacy (ability to use technology for efficient learning), knowledge deepening (ability to use technology to problem solve real-world issues), and knowledge creation (ability to create new knowledge for society). **Information and communication technology (ICT)** is a term often used in place of the terms *instructional technology* and *educational technology*, especially outside the United States. The framework shows how teachers should engage with six aspects of their work—ICT in education, curriculum and assessment, pedagogy, ICT, organization and administration, and professional learning—to plan and design lessons to achieve the three levels in the framework. UNESCO has Teacher Competency Standards Modules for each of these levels. Each module consists of curricular goals, teacher competencies, ability objectives, and example methods.

The Technological Pedagogical Content Knowledge Framework

Teaching is a complex combination of what teachers know about the content they teach, how they decide to teach that content, and the tools they use to carry out their plans. Historically, teacher education has centered on content knowledge and pedagogy as separate concerns. But Shulman (1986) was first to stress the importance of how these "knowledge components" work together rather than separately. Hughes (2000) extended Shulman's concept by adding and emphasizing technology as another component of knowledge needed by teachers. The result is a combination of technological, pedagogical, and content knowledge. Figure 1.4 illustrates how these areas converge and overlap. Teachers who develop **technological pedagogical content knowledge (TPCK or TPACK)** (shown at the center of Figure 1.4) strategically and simultaneously consider

Figure 1.4 TPCK/TPACK Framework



Technological knowledge (TK) is knowledge and use of technology hardware, software, and resources. Example: Using social media (e.g. Blog, Wiki, Facebook)

Pedagogical knowledge (PK) is knowledge about the processes and practices or methods of teaching and learning. Example: Using scaffolding to help students' meaning making and knowledge construction.

Technological pedagogical knowledge (TPK) is knowledge of how technology can support general teaching and learning activities. Example: Using an online quiz for assessment at the end of the lecture.

Content knowledge (CK) is knowledge of subject matter concepts or principles. Example: Knowing properties of geometric shapes.

Pedagogical content knowledge (PCK) is knowledge of how to teach and represent subject matter to students; generating content-specific learning goals; identifying and addressing student subject-specific misconceptions or mistakes; and content-specific assessment strategies. Example: Using analogical skills to teach math concepts.

Technological content knowledge (TCK) is knowledge of content-specific technologies (hardware and software) or content representations (animations or simulations). Example: Using virtual math manipulatives for mathematics curriculum topics.

Technological pedagogical content knowledge (TPCK/TPACK) is knowledge, decision-making, and design of teaching subject matter to students with content-based technology tools or representations and/or using content-specific, technology-based assessment strategies in ways that meet content-specific learning goals and address student subject-specific misconceptions or mistakes. Example: Using a lab for students to study velocity and speed by building a ramp, selecting a moveable object, and collecting velocity and speed data from motion detectors as the object rolls down the ramp; then graphing the resulting data and interpreting the relationship between velocity and speed.

their knowledge of pedagogy, content, and technology to design and integrate technologies into content-based teaching. When developing and using TPCK in their technology lesson design, teachers tend to create lessons that are transformative in the way technology is used to support instruction, student learning, or the curriculum as compared with teachers' previous non-technology-supported lessons (Hughes, 2005; 2013). The transformative lessons tend to put the technology in the students' hands, are content rich, and use technology to situate learning or instructions in ways unattainable without it.

Originally, the TPACK framework was called TPCK (Hughes, 2000). Over the years, other scholars have referred to this concept as *information and communication technology (ICT)-related pedagogical content knowledge (PCK)* (Angeli & Valanides, 2005), *technology-enhanced PCK* (Niess, 2005), and *Technology, Pedagogy, and Content Knowledge (TPACK)* (Thompson & Mishra, 2007). Scholars have not agreed on one term, but TPACK is used often within teacher professional learning industry.

Teacher education programs have come to view the TPACK framework as useful for several purposes. It gives students and their instructors a common vision and language for talking about their technology-related goals and illustrates to students the knowledge they are seeking to develop. Figure 1.4 provides examples of different types of knowledge involved within a TPCK framework. Teachers need preparation putting this knowledge into practice. Voogt, Fisser, Roblin, Tondeur, and van Braak (2013) reviewed the literature on how teacher education programs are using the TPACK framework and found that creating opportunities for preservice teachers to actively design, redesign, and enact technology-supported lessons was a best practice in increasing competencies in teacher educators' technology integration skills.

✓ **Check Your Understanding** 1.3

Shared Writing 1.2 Using Standards to Be a Technology-Using Teacher

Today's Essential Conditions That Shape Technology Integration

To integrate technology successfully into their teaching, educators must recognize that teaching occurs within a myriad of contexts from the classroom to cities, states, and nations. These contexts with their subtleties and complexities influence what educators can accomplish. In addition to the ISTE standards mentioned earlier in this chapter, ISTE also identified 14 essential conditions that influence technology integration in schools. The following sections describe these contextual conditions organized within six areas—educational, political, technical, social, equitable and cultural, and legal and ethical—that influence technology adoption and integration in schools today as summarized in Table 1.2.

Educational Conditions

Educational leadership is a primary condition that influences school-based technology integration. In addition, other educational commitments, such as digital literacy and citizenship, pedagogical practices, and online learning, affect the ways that technology is used in teaching and learning.

TECHNOLOGY LEADERSHIP AND VISION Research demonstrates that effective technology leadership is a significant predictor of teachers' and students' use of

Educational	
Technology leadership and vision Digital literacy/digital citizenship needs Optimal technology-based pedagogy Online learning opportunities	• Educators need to become involved in shared leadership • Technology vision should be learner focused • Students must become good digital citizens • Responsibility falls on schools • Debate involves teacher-directed methods versus inquiry-based methods • Not all students can learn well at a distance • Some states and districts require an online course for graduation
Political	
Visionary technology policies Teacher and student accountability requirements Consistent and adequate funding	• National, state, and local technology plans guide schools • Accountability emphases drive technology uses • Emphasis on innovative teaching strategies is decreased • Schools and district must be creative funders for technology hardware, software, and professional learning
Technical	
Technology infrastructure Technology support Malware, viruses, spam, and hacking	• Schools must establish strong Internet Wi-Fi access to digital devices and high-quality digital content • Teachers require human support for technical problems, lesson design, technology selection, and professional learning • Some software can harm programs, data, and/or hardware • Spam drains time, resources • Phishing schemes can lead to identity theft
Social	
Privacy issues	• Technology-enabled tracking can identify user location, personal information • Wearable devices have the ability to photograph or record surreptitiously • Private information can be made public on social networks
Health	• Technology overuse can cause ailments • Obesity and fitness decline from physical inactivity
Multitasking	• Multitasking can have a negative impact on learning and retention
Online behavior	• Colleges and universities examine undergraduate applicants' social footprints • Teachers can be faulted for social media uses • Cyberbullying involves the use of technology to bully others typically by sending messages of an intimidating or threatening nature
Community engagement	• Educators should create "live" technology plans to share accomplishments and needs within their community
Equity and Culture	
Digital equity	• Students of minority groups have less active technology-supported learning opportunities • Dropout rates from distance courses are higher for already underserved students
Racial and gender equity	• Females and some minorities enter STEM courses and careers at low rates • Technology use by some underserved groups is often limited to remedial rather than empowering purposes
Students with special needs	• Devices and methods to allow equal access remain expensive, difficult to implement
Legal/Ethical Issues	
Academic honesty Privacy	• Online access enables cybercheating • Students and educators must safeguard against copyright infringement • Students' personal data are at risk from loss of privacy, identity theft • It is incumbent on schools to safeguard students' data and privacy
Safety	• Risks of predators and loss of privacy can occur • Acceptable use policies are required
Responsible use Illegal activity	• Ease of illegal access increases software and music piracy • Firewalls attempt to prevent intrusion • Students and others are being prosecuted

technology in schools (Hughes, Boklage, & Ok, 2016; Schrum & Levin, 2013). Administrative leaders such as superintendents and principals are effective technology leaders when they lead collaborative processes for technological goal setting and visioning with stakeholders, such as teachers, staff, parents, and students. Furthermore, research shows more success with technology in classrooms when the technology visions of schools or districts are learning focused, curricular focused, and preplanned (Dexter, 2011; Warschauer, Zheng, Niiya, Cotten, & Farkas, 2014). A technology vision facilitates a systematic implementation process that also involves all stakeholders. For example, implementation could involve parent information meetings, administration of ongoing

> **Video Example 1.2 Collaborative Leadership**
>
> In this video, you'll learn about how good leaders can encourage collaboration and positive relationships within school districts for everyone to work toward a shared vision.
>
> https://youtu.be/cV-1iBGJb7U

polls, systematic teacher professional learning, and evaluations of progress. Finally, formal leaders can empower teachers and others to be part of a **distributed leadership** network that collectively shares responsibility for achieving goals. For example, Dexter (2011) found that teachers who were involved in technology committees facilitated input to school leaders, peer learning reduced teacher isolation, and giving credit to staff and students for progress toward goals increased buy-in.

DIGITAL LITERACY AND DIGITAL CITIZENSHIP The increasing role that technology plays in all areas of our society makes it ever more essential that students become critical consumers of technology resources and demonstrate **digital citizenship**, the use of technology resources in safe, responsible, and legal ways. As more digital resources are created, students need to develop **digital literacy** skills, which enable them to (1) access, evaluate, and manage information, (2) analyze digital media for their underlying message and purposes, (3) use media creation tools for expression, and (4) understand legal and ethical uses of digital technology. The responsibility for this instruction usually falls on schools.

OPTIMAL TECHNOLOGY-BASED PEDAGOGIES Educators continue to debate the roles of traditional, teacher-directed methods versus student-centered, constructivist methods. Long-used and well-validated teacher-directed uses of technology can address content standards, but many educators see teacher-directed methods as not building long-term, flexible knowledge. Inquiry-based, student-centered, constructivist methods are considered more modern and innovative, and there is emerging research revealing that these approaches can lead to higher learning gains. For example, in a comparison of a story-based and game-based curriculum to teach persuasive writing, learning gains and engagement for students were significantly higher in the game-based curriculum (Barab et al., 2012).

ONLINE LEARNING OPPORTUNITIES Increasing numbers of virtual K–12 courses are being offered, and virtual schools are becoming a mainstream part of U.S. education. Although this movement has increased access to high-quality courses and degrees, not all students have the skills needed to use them should they gain access. Recognizing that learning at a distance is rapidly becoming commonplace in higher education, some states including Michigan, Florida, Virginia, and Alabama and some school districts, such as Putnam County, Tennessee, have made completing a distance course a high school graduation requirement.

Political Conditions

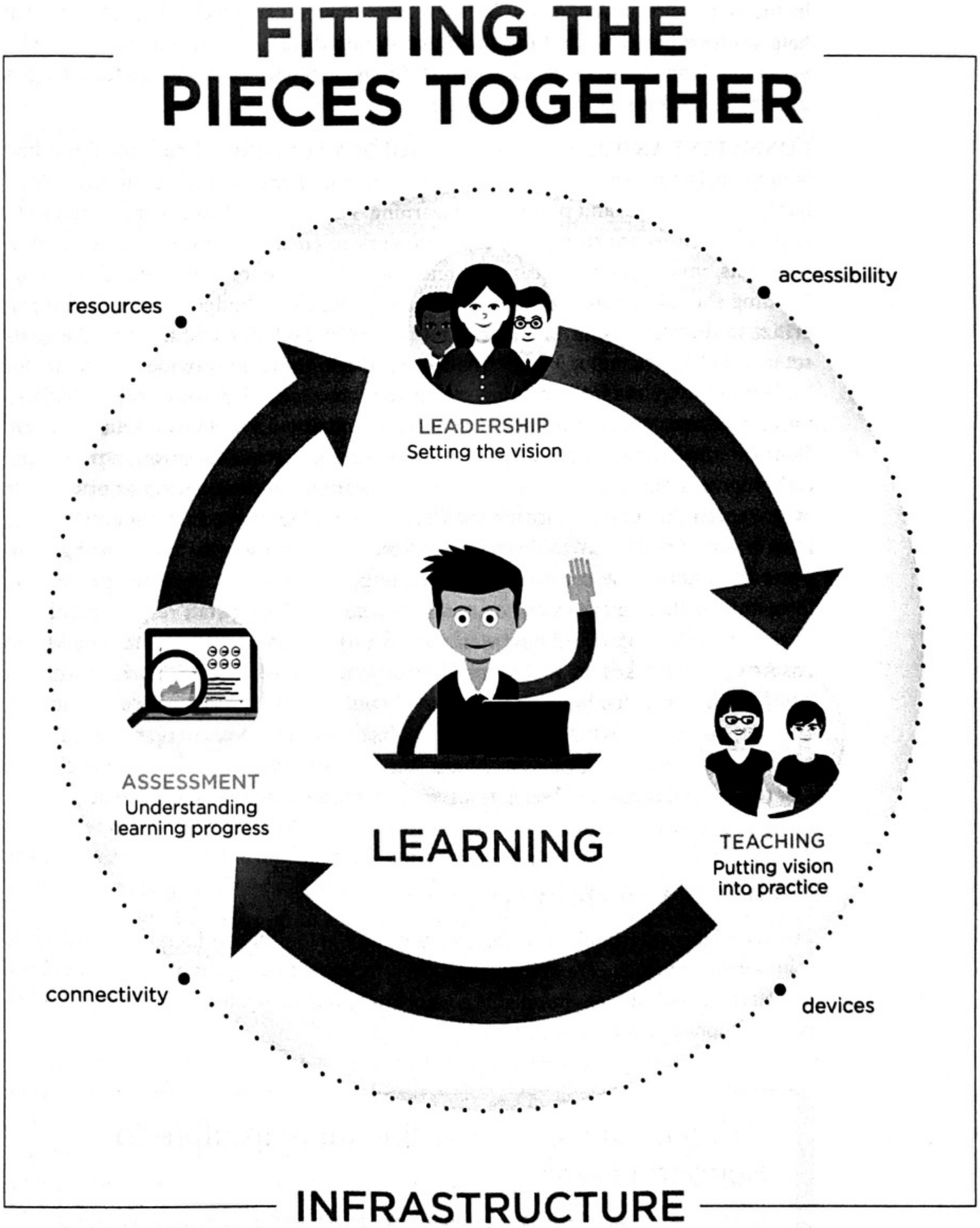
We all live in a political world with frequent changes in national, state, and local governance. Public schools were established based on democratic ideals of free, universal, and nonreligious schooling available for all. Federal governance through the U.S. Department of Education and state and local governance have varying responsibilities toward the organization, funding, and curriculum of public schools.

VISIONARY TECHNOLOGY POLICIES Technology integration is influenced by national, state, and local policies and priorities. The USDOE's Office of Educational

Technology creates a national educational technology plan (NETP) about every 4 to 6 years. The 2016 National Educational Technology Plan, Future Ready Learning: Reimagining the Role of Technology in Education (Office of Educational Technology, 2016) set forth the vision and plan for the nation for learning with technology. This plan positions leadership, teaching, and assessment as crucial elements to ensure visionary learning with technology that is enabled through accessible digital devices and resources for everyone with connectivity (see Figure 1.5). Each state has an educational technology

Figure 1.5 U.S. National Educational Technology Plan Infographic

Office of Educational Technology. (2016). *Future ready learning: Reimagining the role of technology in education.* U.S. Department of Education. http://tech.ed.gov/netp/



plan, and districts create technology plans that assist in setting local goals and securing grants and other funding. As an educator, you can also create a classroom technology plan to help guide your technology integration efforts.

TEACHER AND STUDENT ACCOUNTABILITY FOR QUALITY AND PROGRESS The Every Student Succeeds Act (ESSA) effective in the 2017–2018 school year replaces its predecessor, the No Child Left Behind (NCLB) Act. ESSA gives more decision-making authority to the states. States are now able to adopt challenging academic standards that could or could not be the Common Core State Standards. States still must test students in reading and math in grades 3 through 8 and once in high school, but there is more latitude in regard to which tests to use. There are changes to how Title 1 funds can be used, which could allow schools to use these funds for schoolwide programs, which include educational technology. A strong trend toward using technology in ways that help students pass tests and meet required standards rather than support more innovative teaching strategies could continue. Teachers might hesitate to use technologies unless they address accountability goals.

CONSISTENT AND ADEQUATE TECHNOLOGY FUNDING Educational funding is not consistent, which means that funds are not always available for technology hardware, software, and professional learning. Funding challenges come when technology expenses are rising and districts work to create ubiquitous learning environments, invest in online learning, and adopt software for personalized learning. Funding should be considered an ongoing expense in the budget, and it should prioritize technology resources that support enacting the vision and meeting the goals set in a district technology plan. The federal E-rate program provides discounts for high-speed, wireless Internet connectivity for schools and libraries, especially those in rural areas or with large student populations qualifying for free or reduced lunch. Districts and schools should pursue federal funding available through other special programs, but these require lengthy applications, and not all states or districts are awarded the funds. To lower costs, some technology advocates suggest shifting from licensed textbooks to open licensed educational resources, eliminating computer laboratories and copy machines, creating partnerships to leverage purchasing discounts or share infrastructure or staff, and reconsidering staff responsibilities to streamline roles and avoid new staff costs. Considerable care needs to be taken to ensure that workloads are maintained, not expanded. For example, in a case study of a high school special education teacher using one-to-one iPads in her classroom, Ok, Hughes, and Boklage (2017) found that a shift from textbooks to open educational resources essentially shifted the responsibility to the teacher to find, research, choose, and request purchases of apps. The teacher reported this responsibility to be prohibitively time consuming.

Technical Conditions

The availability of technology is a necessary condition for teachers to be able to integrate it into their curricula. Schools can establish a technological environment for teaching and learning, but such environments are not always equal given educational and political conditions previously described.

Video Example 1.3 Flexible Infrastructure to Support Learning

In this video, Joplin School District leaders describe how they adopted open education resources instead of textbooks in their one-to-one laptop high school.

https://youtu.be/OixVlc92Uzc

TECHNOLOGY INFRASTRUCTURE For educators to use technologies in their classrooms, schools must build a robust technological infrastructure. The elements in this infrastructure should be driven by the vision and goals of a technology plan. At a minimum, schools should establish ubiquitous, strong Internet Wi-Fi connectivity, access to digital devices for teaching and learning, and availability of high-quality digital content such as simulations, e-books, and videos. The goals of each individual school or district should guide the specificity of the infrastructure. For example, some schools provide Internet connectivity for children at home. Some schools allow students to bring their own devices (BYOD) or technology (BYOT), and others sponsor one-to-one tablet or laptop environments, both increasing mobile-supported learning. Some schools are using open educational resources or purchasing e-textbooks and other apps to support teaching and learning.

TECHNOLOGY SUPPORT Educators also need support staff to assist with technical difficulties, technology-supported lesson design, technology selection, and professional learning opportunities focused on technology. Some schools have dedicated technology specialists who contribute to meeting all these responsibilities. Some schools must share support staff across one or more other schools. Large schools, in contrast, could have multiple staff in these support roles. Librarians and media specialists can also offer technical assistance. Finally, some support could be outsourced to companies that provide infrastructural resources to the school; these companies could accommodate technical inquiries via phone calls, emails, web chats, or video conferencing.

MALWARE, VIRUSES, SPAM, AND HACKING **Malware**, short for malicious software, can damage, destroy, and disrupt operations or spy on computer operations. **Viruses**, a type of malware, are programs written specifically to do harm or mischief to programs, data, and/or hardware. They include **logic bombs, worms,** and **Trojan horses**. **Spyware** is malware that secretly gathers information, including addresses, passwords, and credit card numbers stored on a computer, to use for identity theft. For instance, computers can be implanted with a program that enables outside control without the owner's knowledge. Often malware is installed when a user opens an email attachment, which secretly installs spyware or a virus on the computer, or when a user installs software downloaded from an unknown source. **Spam**, or unsolicited email messages or website postings, come with such frequency that they interfere with computer work. Schools have dedicated considerable resources to blocking malware. Computer users sometimes respond unwittingly to **phishing** attempts, which are emails that falsely claim to be from a legitimate business in order to glean private information for identity theft. For example, a teacher could receive a message purporting to be from the school district's information technology department asking all users to update their records with passwords and other information. If the teacher supplies this information, the phisher can access the teacher's account, which could contain a great deal of private information. Educators should always check email addresses carefully before opening attachments, never log in to a site or provide private information when an email requests it, and download software only from reputable company websites.

Social Conditions

Technology both responds to social conditions and contributes to new social norms with societywide implications. School systems have recognized that the social conditions described in this section impact every school's mission and classroom climate and must be addressed by sound policies and a planned, ongoing education program to make teachers and students aware of these concerns and to limit possible negative impact.

PROTECTING PERSONAL PRIVACY Adaptive learning software's ability to track users' clickstreams raises concerns regarding ownership, control, access, use, security, and privacy of the data. **Global positioning system (GPS)** technologies in combination with cell phone software features make it possible to pinpoint a user's exact location and can communicate a great deal of that person's private information to others, usually without the user's knowledge. Some have decried schools' use of ID cards or **radio frequency identification (RFID)** to track students' attendance and whereabouts as an attack on privacy. Social network users who do not understand the often complex privacy settings mistakenly believe that their information is private, but it can be available publicly. Technologies such as Google Glass are wearable devices that make it possible to record video or images without others' awareness and continue to challenge our definitions of what is private. Young people are often unaware that their cell phone uses are not private and, thus, might not hesitate to send out explicit photos or messages, a practice known as **sexting**. Even videos shared anonymously online can be identified if required by law.

HEALTH Potential problems such as hearing loss from headphone use or eye strain from gazing too long at digital screens have been identified and continue to be studied. Time spent at video games and computer work is time taken away from actual physical activity, which can contribute to obesity and decline in fitness.

MULTITASKING Many young people feel that they excel at **multitasking**, or doing several (usually technology-enabled) activities at the same time. However, studies have shown that the practice negatively affects both accuracy and information retention. Texting while driving has proven to be a serious threat to public safety. Cell phone use during school can disrupt learning activities and even be used for cheating on schoolwork or tests.

ONLINE BEHAVIOR Time spent on social networking is often time taken away from schoolwork (Goodman, 2011). Students are often unaware that admissions personnel from some colleges and universities review and consider information on students' social networking sites (e.g., Facebook). Teachers who have their own social networking sites have encountered criticism or even been fired for ill-advised personal posts and contact with students. Online harassment in digital environments known as **cyberbullying** is defined as involving aggression, repetition, and imbalance of power (Olweus, Limber, & Mihalic, 1999), and technology enables the online persistence and visibility of the acts of cyberbullying (Boyd, 2014). It mirrors similar bullying on school campuses.

Video Example 1.4 Preventing Cyberbullying

In this video, listen to a fourth-grade teacher talking about strategies to combat cyberbullying.

COMMUNITY ENGAGEMENT Social connections with a school's community base can support reaching the school's technology goals and vision. Many underfunded schools and districts need voter-approved bond measures to fund technology procurement. These measures are more likely authorized in districts where explicit outreach and information sharing with the community, including parents, elders, and business owners occur. We recommend that the technology plans of teachers, schools, and districts be live, online, interactive sites where goals, accomplishments, and needs are clearly articulated and available to the public when possible.

Equitable and Cultural Conditions

Technology is a double-edged sword, especially for education. It presents obvious potential for changing education and empowering teachers and students but can also further divide members of our society based on race, ethnicity, or national origin; sex; sexual orientation or gender identity or expression; disability; English language ability; religion; socioeconomic status; and geographical location. Teachers lead the struggle to make sure that their technology use promotes rather than conflicts with the equitable goals of a democratic society.

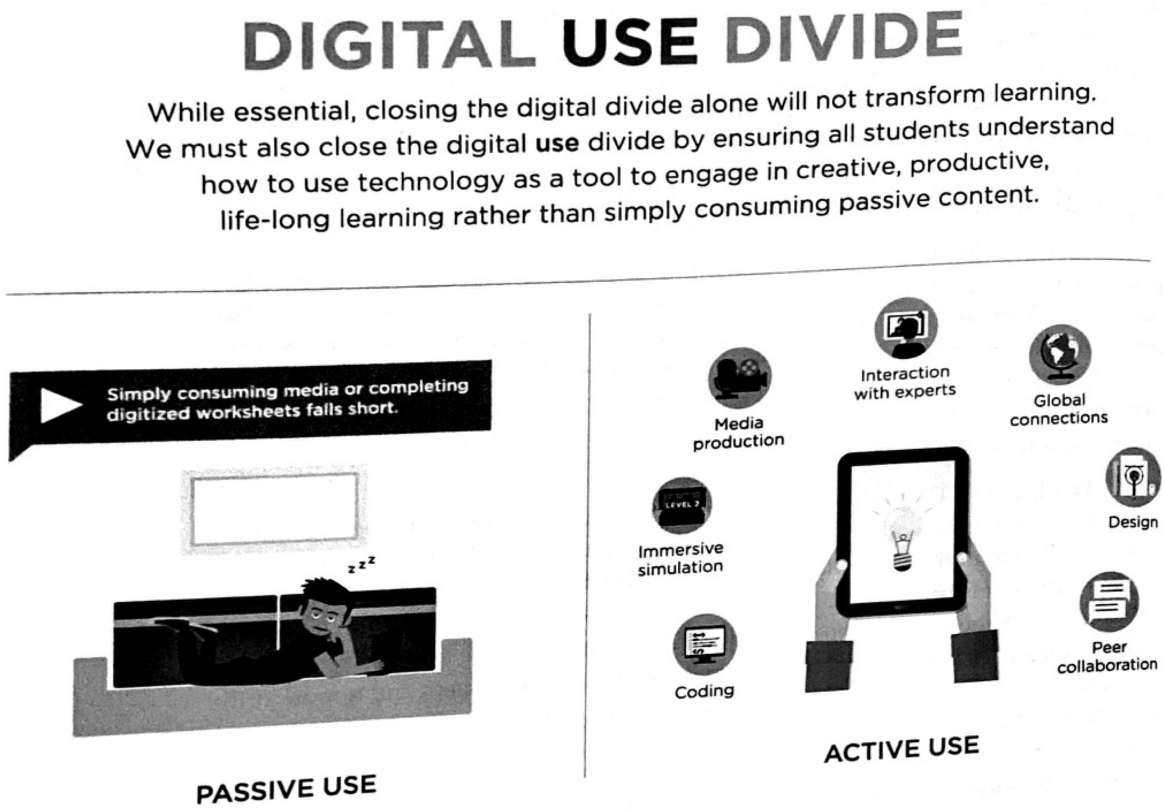
DIGITAL EQUITY Originally when discrepancies in access to technology resources occurred among groups of different socioeconomic, race, or gender distributions, it was referred to as a **digital divide**. More recently, the term **digital inequity** has expanded the concept from solely unequal access to the unequal educational opportunities involving technologies. Although low-income and minority students have more access to technologies than ever before (sometimes surpassing their more affluent and nonminority peers) (Lenhart, 2015), their access to active (versus passive), technology-supported learning opportunities in schools is not always the same. For example, Hughes, Read, Jones, and Mahometa (2015) discovered inequities in home and school technology use according to students' race and school urbanicity. Furthermore, dropout rates from distance courses by underserved students more than others are higher than for physical schools, which creates digital inequity. Figure 1.6 exemplifies that passive and active digital uses are very different, and we must ensure that all students engage in active technological uses.

RACIAL AND GENDER EQUITY Women and people of color earn far fewer degrees in **science, technology, engineering, and math (STEM)** areas (Musu-Gillette et al., 2016) and enter STEM careers at lower rates than males and whites. Many educators believe that less frequent use of technology leads to disinterest in technical careers. Programs such as Black Girls Code or Girls Who Code enable young girls to learn computer programming and meet women role models. In addition, children in remedial programs can have access to computers, but they often use them mainly for remedial, passive work rather than for active work such as email, multimedia production, and other personal empowerment activities.

EQUITY FOR STUDENTS WITH SPECIAL NEEDS There is an increasing emphasis on **accessibility** in the development of technological hardware, software, apps, learning environments, and digital content using **universal design**. Technology is intended to be used universally by all learners including students who have disabilities, are English learners, or are in locations with low availability of Internet or electricity. For example, technological resources can have built-in text-to-speech capabilities; variable font size, color, and type manipulations; screen zooming; multimedia output (video, audio, text); translation capabilities; high performance rechargeable batteries, and built-in Wi-Fi. Students with disabilities who have **individualized education programs (IEPs)** could have even more specific assistive technology resources included in the program; if so, providing these resources is guaranteed by federal laws. See ways that teachers can better meet the needs of these students in Box 1.1. Also see how Coachella Valley Unified

Figure 1.6 Digital Divide Infographic

Office of Educational Technology. (2016). *Future ready learning: Reimagining the role of technology in education.* U.S. Department of Education. http://tech.ed.gov/netp/



School District addressed the lack of availability of Internet in the later section "Trend 3: Ubiquitous Mobile Computing."

Legal and Ethical Conditions

The legal and ethical issues that educators face reflect those of the larger society as technological innovations change common activities. The major types of ethical and legal issues discussed next require district and schools to adopt policies to govern acceptable

Box Feature 1.1: Adapting for Special Needs

Assistive Technologies and Universal Design Resources

Teachers increasingly recognize that some students have difficulty accessing and engaging in typical classroom learning activities. For example, some students with a physical disability might be unable to use the standard textbook or to comprehend its content because of a learning disability. In situations like these, teachers are encouraged to consult with their district's assistive technology specialist. Specialized technologies that are used by only a small number of students are known as *assistive technologies*. To learn more about what assistive technology is and how it can be used, visit the National Public Website on Assistive Technology.

In recent years, the notion of using technology to support academic performance has expanded from assistive technology for some individuals to universal design for learning (UDL) applications that benefit all students. UDL interventions provide multiple means of support to diverse students by providing choices for how they access and engage in the curriculum and how they demonstrate what they know.

—Contributed by Dave Edyburn

activities. These conditions are applicable to all school stakeholders: school leaders, teachers, students, parents, and visitors.

ACADEMIC HONESTY Increased online access to full-text documents on the web has resulted in increased incidents of student plagiarism, a practice often referred to as **cybercheating** or online cheating. Sites have emerged to help teachers catch plagiarizers, and teachers are trying to structure assignments that make plagiarism more difficult. Schools also are concerned about whether students signed up for an online course are actually the ones doing the work. Some organizations have moved to proctoring systems with either cameras or biometric sensors to monitor students; others have students come to a specific location to take required exams. To make sure that everyone complies with **copyright laws**, which give the creator of original works exclusive rights to use and profit from it, schools are making teachers and students aware of policies about copyright, Creative Commons copyright, and guidelines for fair use of published materials. **Creative Commons** expand the ways that creative works can be shared and legally used through a range of licenses that vary in users' ability to copy, distribute, and remix content for noncommercial use. **Fair use** gives limited rights to those who want to use brief excerpts of copyrighted material without the need for permission.

STUDENT PRIVACY As more and more digital data are generated in the daily activities of educators and learners, data use policies ensure the appropriate safeguarding of student data. Typically, the protected data might be in a **Student Information System (SIS)** software or might be personally identifiable information, such as a student name or picture, in online software like blogs or wikis. Several federal laws have protections for student education records and personal information, such as the Family Educational Rights and Privacy Act (FERPA), the Protection of Pupil Rights Amendment (PPRA), the confidentiality provisions in the Individuals with Disabilities Education Act (IDEA), and the Children's Online Privacy Protection Act (COPPA). A data use policy helps educators understand what data are acceptable to access and use and in what ways.

SAFETY As students spend more time in online environments, attempts by online predators to contact students are more likely, and obscene material, sometimes referred to as **cyberporn** (Levy, 2010), is readily available and easy to access. The federal Children's Internet Protection Act (CIPA) requires school districts that accept E-rate funds to build their Internet infrastructure, which includes most districts, to block or filter children's access to obscene, pornographic, or harmful pictures on the Internet. Filters are not 100% accurate, so students also need to be educated as to what is information is acceptable to access. To address these concerns, schools are requiring students, parents, teachers, and staff to sign an **acceptable use policy (AUP)** that outlines appropriate use of school technologies for students and educators.

RESPONSIBLE USE An increasing number of sites offer ways to download copies of software, music, or media without paying for them, a practice known as **software piracy** or **music piracy**, and software and media companies are prosecuting even young offenders. Teachers are tasked with modeling and teaching ethical behaviors related to software and media use.

ILLEGAL ACTIVITY **Hackers** are those who use online systems to access nonsecure computers to commit identity theft and other malicious acts. In some cases, students have hacked into their own school's computers as acts of vandalism. To combat these problems, schools install **firewalls**, software that blocks unauthorized access to classroom computers, require authenticated log-in to all computers, and spend large portions of technology funds each year to prevent and clean up after illegal activities. In recent years, students have used apps, social media, and other Internet tools to threaten violence—which fortunately are mostly hoaxes—to avoid tests, miss school, or get a thrill through "swatting," that is, drawing the local SWAT team to a site. However, police and FBI quickly become involved and easily identify and prosecute swatters.

Check Your Understanding 1.4

Schools and districts must constantly educate teachers and students on strategies to prevent these illegal activities.

Emerging Trends in Technological Resources

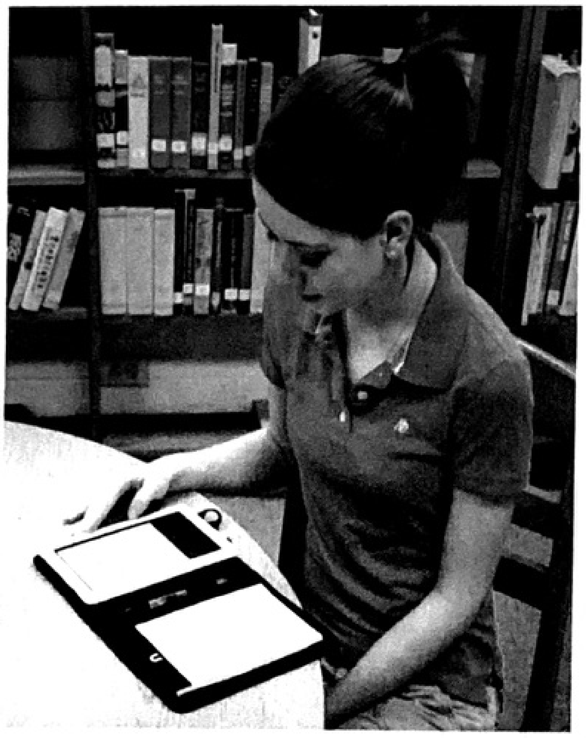
Visions of the future are suffused with images of technologies that may seem magical and far fetched now, just as wearable technologies such as an Apple Watch seemed only a few years ago. We know that future education will mirror current technical trends and shape the goals and priorities we set today for tomorrow's education. As with so many "miraculous" technologies, the question is how we will take advantage of their capabilities to bring about the future education systems that our society wants and our economy needs.

Trends in Hardware and Software Innovation

For emerging developments with great potential for impact on education, one resource is the annual report of the New Media Consortium's Horizon Project that identifies and describes emerging technologies that are likely to have great impact on K–12 education. Another source is the National Science Foundation's cyberlearning program begun in 2011; it has awarded hundreds of grants amounting to over $100 million for learning innovations in education that leverage cybertechnologies.

TREND 1: INCREASED E-BOOK AND E-TEXT PRESENCE Although e-texts have been available for decades, their technical sophistication has recently increased dramatically. They are rapidly replacing paper books as the dominant medium for accessing information. Publishers of textbooks are quickly generating digital content options for schools. The student in the accompanying photograph is reading an e-book.

TREND 2: INCREASED SOURCES OF OPEN CONTENT Open-source materials are created to be shared, adapted, and used by others without fees but with required attribution to the creator of the materials. Some open content is created in small modular formats that allow flexible incorporation into learning experiences. This trend also means the availability of more free content that can be adapted for K–12 teachers and students.



E-book reading via mobile device

TREND 3: UBIQUITOUS MOBILE COMPUTING The trend toward mobile devices in education is already widespread and having a great impact on K–12 education. The portability of tablet devices facilitates instant off/on, ubiquitous Internet access, rapid communication, and access to e-texts. A thriving app development movement for tablets is driving this trend and increasing the options they enable. Cloud-based storage and communications also enable this trend. Some schools allow students who already own personal technology devices to use them in classes, creating a BYOD/BYOT environment. Then these schools invest in mobile devices only for students who don't have them. Concerns about curriculum, privacy, classroom management, and uniform access abound. In the Coachella Valley Unified School District in California, many students live in rural sections of the district where the local cable company would not install fiber optic

Video Example 1.5 24/7 Connectivity: Wi-Fi Powered Buses

Watch this video to see how this district outfitted their school buses overnight near the Internet-poor zones to maximize students' use of mobile technologies.

https://youtu.be/YZNGz-qiVHE

cables to support Internet access. The district outfitted their school buses with solar-powered Wi-Fi and parked many of the buses overnight near the Internet-poor zones to maximize students' use of mobile technologies.

TREND 4: ROBOTICS Affordable hardware, such as Arduinos, Raspberry Pi, and some 3D scanners, have enabled more schools to adopt a robotic engineering curriculum to support learning in science, technology, engineering, and mathematics (STEM) for K–12 students as an after-school extracurricular activity or as part of a STEM discipline. Students engage in a range of activities from computer programming, using robot controllers, switches, sensors, motors, and LEGO kits to design, build, and program robots—often for competitions. For Inspiration and Recognition of Science & Technology (FIRST) is a nonprofit organization that offers LEGO-based robotics programs and competitions for children ages 6–14 who research real-world scientific problem and offer prototypes of innovative solutions. NASA also supports robotics education through the Robotics Education Project (REP). It provides a list of curriculum, competitions, and internships appropriate to K–5, 6–8, and 9–12 grade levels and higher education. Research and development activities at Carnegie Mellon University include building tools and curriculum for robotics classrooms that engage learners beyond basic skills toward sophisticated **computational thinking** (Shoop, Flot, Friez, Schunn, & Witherspoon, 2015). Figure 1.7 shows a girl and a boy involved in STEM activities.

TREND 5: LEARNING ANALYTICS Educators are also paying increased attention to **learning analytics**, or the ability to detect trends and patterns from sets of performance data (a.k.a. "big data") across large numbers of students. The goal is to find ways to apply findings across students to create a personalized approach to learning for each student.

Figure 1.7 Girls and boys learning through robotics

TREND 6: AUGMENTED REALITY SYSTEMS Coined by a Boeing researcher in 1990, **augmented reality (AR)** refers to a combined hardware and software platform that creates a computer-generated environment in which a real-life scene is overlaid with information that enhances our uses of it. Examples have been evident in industry, military, and entertainment environments for years, and now versions of these systems are available to schools on mobile devices. For example, one teacher used an augmented reality app called Aurasma to let students hover their tablets over images of famous paintings, thus calling up audio and text with features and notes about the artist's techniques. Other augmented reality apps include Layar, used to enhance print materials, and colAR, which works with coloring book pages. The National Science Foundation has funded a project in which students engage in (AR) with their mobile devices to inquire into local historical sites in the present day and in different time periods and from different social perspectives. Another project, EcoMOBILE, allows students to examine ecological aspects of a local pond using phones and AR technology.

TREND 7: WEARABLE TECHNOLOGIES In combination with augmented reality, a trend noted previously involves wearable technologies such as Google Glass and smart watches that are anticipated to impact education as new applications come on the market. Mineer (2014) cites predictions that BYOD will segue into wear your own device, or WYOD. She describes one teacher's uses of Google Glass to record lectures as she gives them and lets students record their progress on projects they are completing. Wearables such as AiQ's "smart textiles," which monitor the wearer's vital signs, and Recon Instruments' sports goggles or FitBit wristbands, which monitor movements, have great potential for health- and sports-related areas. Another project provides **head-mounted displays (HMD)** to children who are deaf so they can quickly move from watching a person signing (in the HMD) to observing scientific phenomena in real time. Other wearable products track location data, offering the potential for improving student safety in school settings.

TREND 8: GESTURE-BASED COMPUTING Devices that we can control by moving a hand or other body part are changing the way people interact with computers. With **gesture-recognition systems**, a camera or sensor reads body movements and communicates them to a computer, which processes the gestures as commands and uses them to control devices or displays. Gesture-based technology, especially in combination with wearable technologies, has the potential to enhance teaching simulations by making them more lifelike and intuitive to use.

Educational Trends Leveraging Technology Innovations

Hardware and software developers are capitalizing on the ever-expanding computing power of computers and high-speed Internet to create a range of resources that can be harnessed to transform the educational system. More and more, people expect to work, learn, and study whenever and wherever they want to, and they seek instructional resources that are responsive to their personal needs.

TREND 1: MAKERSPACES Inspired by *MAKE* magazine and Maker Faire, a community gathering begun in 2006, **makerspaces** are physical spaces with digital and mechanical tools and materials where students learn to design, tinker with, and build tangible objects. Schools have begun to establish makerspaces in libraries and other available spaces. Multidisciplinary activities can draw from computer and technical education, home economics, STEM disciplines, art, and music. **3-D printers**, often found in makerspaces, build physical models in plastic or other material one layer at a time from 3-D modeling or CAD software. Some makerspaces are full of technologies such as Arduinos, Raspberry Pi, and scanners; others repurpose items such as newspaper and cardboard. Kat Sauter reported that some of her students in their makerspace at

The Ann Richards School for Young Women Leaders in Austin, Texas, designed and created a preschool playhouse, and other students focused on creating an app for school information (Breedlove, 2015). Makerspaces are less about the specific outcome and more about the process of design, inquiry, and making.

TREND 2: COMPUTATIONAL THINKING With recent emphasis on science, technology, engineering, and mathematics (STEM), **computer programming**, **making**, and robotics in the United States, educators have begun to coalesce around the value of having students learn computation thinking skills. Definitions of **computational thinking** vary but the aim is to develop students with knowledge and skills in problem solving, design, inquiry, abstraction, quantitative reasoning, data analysis and interpretation, modeling, computer programming, pattern identification, conditional logic, algorithms, and symbol systems. Students use creative ways of thinking in computer science to break down, model, and explore phenomena and to identify explanations or solutions through the use of computers. The Computer Science Teacher Association (CSTA) is a resource for current concepts, curricula, and assessments regarding computational thinking, but all teachers should learn about it because it is one of the 2016 ISTE Standards for all students.

TREND 3: ONLINE LEARNING As high-speed connections become more readily available in schools and homes and handheld devices such as tablets become capable of online access, more students are taking online courses. The number of virtual schools operating across states is increasing (Gemin, Paper, Vashaw, & Watson, 2015), and some schools now offer a completely online diploma. Although controversies such as funding and quality control exist, distance learning for K–12 students eventually will have the same impact on reshaping schools as it has had on redefining higher education.

TREND 4: MASSIVE OPEN ONLINE COURSES Massive Open Online Courses (MOOCs) have heralded a new way to look at learning for free. One of the outcomes of the open-content movement, MOOCs hold the promise of a future where education is less expensive or free and available to anyone anywhere in the world. MOOCs might not be used in formal K–12 schools because of student privacy issues, but they can be useful for educators' professional learning or for identifying resources for the classroom. For example, The Exploratorium in San Francisco developed a MOOC to introduce the fundamentals of "tinkering" to educators as a form of professional development (Exploratorium, 2015).

TREND 5: IMMERSIVE PHYSICAL AND VIRTUAL ENVIRONMENTS New environments and tools that use augmented reality and **virtual reality (VR)** are being created to integrate the physical world with virtual elements to engage learners in understanding conceptual or hard-to-replicate phenomena. For example, RoomQuake is an earthquake simulation system that allows students over the course of several weeks to experience and analyze data from earthquakes to identify the fault line (Moher, n.d.). SimBio is a virtual biology lab offering simulated open-ended experiments. Researchers (Meir, Abraham, Klopfer, & Li, 2012) are developing dynamic formative assessment to enable better learning. Virtual reality has become more mainstream in society, which is demonstrated by the availability of low-cost Google Cardboard viewing devices that pair with mobile phones. News agencies, such as *The New York Times*, publish (VR) extensions to many of their news stories (*The New York Times*, 2016). Google Expeditions help teachers take students on virtual fieldtrips (Google, 2016).

TREND 6: GAMES AND GAMIFICATION Games have been found to profoundly engage learners and lead to learning gains in subject matter, a key aspect of what researchers call a **serious game**. **Gamification**, or incorporating the most motivational aspects of games (e.g., badges awarded for success) into nongame activities, is attracting more attention from both software developers and educators. The hope is that driving interest and rewarding student achievement can increase the time spent on learning activities.

TREND 7: PERSONALIZED LEARNING Learning analytics has driven a fast-growing trend toward **personalized learning systems (PLS)**, or computer-based instructional and management programs, that (1) assess individual student learning needs using complex algorithms and collections of data across students and (2) provide a customized instructional experience matched to each student.

TREND 8: EDUCATIONAL OPTIONS FOR STUDENTS WITH LEARNING NEEDS New technologies continue to make the most dramatic advances in opportunities for people with special learning needs. With more hardware and software developers using universal design principles, more future technologies will be used by all people. Specific innovations will be designed for targeted needs. For example, an NSF-sponsored project has developed an interactive robot with gestures and facial expressions for Chinese conversational language learning (RALL-E project, 2016).

✓ **Check Your Understanding 1.5**

Chapter 1 Summary

The following is a summary of the main points covered in this chapter.

1. **The "Big Picture" on Technology in Education**
   - This chapter's big picture review provides an important framework for viewing the field and consists of key terminology, reflections on the past, considerations about the present, and a look ahead to the future.
   - Five perspectives help define today's educational technology: (1) educational technology as communications media, originally represented by Association for Educational Communications and Technology (AECT), (2) educational technology as instructional systems and instructional design, originally represented by International Society for Performance Improvement (ISPI), (3) educational technology as vocational training, originally represented by International Technology and Engineering Educators Association (ITEEA), (4) educational technology as computer systems (a.k.a., educational and instructional computing), originally represented by International Society for Technology in Education (ISTE), and (5) educational technology as learning sciences, originally represented by International Society of Learning Sciences (ISLS).
   - Important definitions in the field are:
     - Educational technology—*Technology resources* leveraged to support educational *processes* involved in addressing teaching and learning.
     - Integrating educational technology—The process of identifying educational problems of practice and matching those with technological resources as possible solutions, using the resources as educational technology in the classroom, and assessing impact on the identified problems.
   - Digital technology resources include:
     - Hardware—Seven types of technology hardware are commonly used in or support today's classroom including (1) networks, (2) computers, (3) handheld technologies, (4) display technologies, (5) imaging technologies, (6) peripherals, and (7) external storage.
     - Software—Educator use of productivity, instructional, and administrative software for teaching and learning activities.
   - Technology support and expertise resources can be found among support staff, school leaders, and parents and students as well as in technology policies and procedure documents.
2. **How the Past Shapes the Present and Future**
   - The educational computing/technology comprises five eras: the mainframe era (1950–late 1970s); the microcomputer era (late 1970s–1993); the Internet era (1990s); mobile technologies, social media, and open access (2001 and continuing); and the personalized, adaptive learning era (2008 and continuing).
   - We have learned the following from the history of technology in education: No technology is a panacea for education; teachers usually do not develop technology materials or curricula; "technically

possible" does not equal "desirable, feasible, or inevitable;" technologies change faster than teachers can keep up; older technologies can be useful; and teachers always will be more important than technology.

3. **Today's Educational Technology Standards and Teaching Competencies**
   - The Common Core State Standards, state-specific standards, and national content area standards all contain ways that digital technologies are involved in subject-area content proficiencies.
   - ISTE Standards for Students and Educators, 21st-Century Skills for Students and Teachers, and the ICT Competency Framework for Teachers address expected technological knowledge, skills, and attitudes for students and teachers.
   - The TPACK framework provides educators a common vision and language for the technological knowledge accessed when designing and integrating technology in the classroom.
4. **Today's Educational Technology Conditions That Shape Technology Integration**
   The following shape technology integration:
   - Educational conditions such as technology leadership and vision, digital literacy and digital citizenship, optimal technology-based pedagogies, and reliance on online learning opportunities.
   - Political conditions such as visionary technology; national, state, and local policies; teacher and student accountability for quality and progress; and consistent and adequate technology funding.
   - Technical conditions including technology infrastructure; technology support; and malware, viruses, spam, and hacking activities.
   - Social conditions related to privacy, health, multitasking, online behavior, and community engagement.
   - Equity and cultural conditions including digital equity, racial and gender equity, and equity for students with special needs.
   - Legal and ethical issues such as academic honesty, privacy, safety, responsible use, and illegal activities.
5. **Emerging Trends in Technological Resources**
   - Trends leveraged by hardware and software innovation include e-texts and e-books, open content, ubiquitous mobile computing, robotics, learning analytics, augmented reality systems, wearable technologies, and gesture-based computing.
   - Educational trends leveraged by hardware and software innovation include makerspaces, computational thinking, online learning, massive open online courses (MOOCs), immersive physical and virtual environments, games and gamification, personalized learning, and increased educational options for students with learning needs.

Technology Integration Workshop

1. Apply What You Learned

As introduced in this chapter, the TPCK framework is a key concept in teacher preparation programs that seek to develop growth in the ability to integrate technology into content-area instruction. Complete the following to expand your understanding of TPCK and its role in your learning:

- Review Application Exercise 1.1 that provides definitions and examples of the TPCK knowledge areas. Generate a new example for the six types of knowledge (e.g., CK, TK, PK, PCK, TPK, TCK) that you feel you possess at this point in your development.
- Sketch a lesson idea that would involve a teacher possessing and using TPCK in the development and enactment of the lesson. Be sure to explicitly state the TPCK on which the teacher is drawing.
- Your ability to reflect on and measure your own growth in TPCK is important. What knowledge areas do you feel need growth before you begin your teaching career?