Roblyer • Hughes

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Integrating EDUCATIONAL TECHNOLOGY *into Teaching*

Transforming Learning Across Disciplines

Integrating Educational Technology into Teaching: Transforming Learning Across Disciplines

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Library of Congress Cataloging-in-Publication Data

Names: Roblyer, M. D., author. | Hughes, Joan E., author.

Title: Integrating educational technology into teaching : transforming learning across disciplines / M.D. Roblyer, Nova Southeastern University (retired), Joan E. Hughes, The University of Texas at Austin.

Description: Eighth Edition. | New York : Pearson Education, Inc., [2018] |

Audience: Ages: 18+

Identifiers: LCCN 2017043408| ISBN 9780134746418 | ISBN 0134746414

Subjects: LCSH: Educational technology—United States. | Computer-assisted instruction—United States. | Curriculum planning—United States.

Classification: LCC LB1028.3 .R595 2018 | DDC 371.330973—dc23

LC record available at https://lccn.loc.gov/2017043408

10 9 8 7 6 5 4 3 2 1

Pearson

Student Edition

ISBN 10: 0-13-474641-4

ISBN 13: 978-0-13-474641-8

For Bill and Paige Wiencke, whose love is, as Arthur Clarke said of advanced technology, indistinguishable from magic.

—MDR

For my father Thomas A. Hughes (1933–2017) whose commitment to education and lifelong learning is my inspiration.

—JEH

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**.

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 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.

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

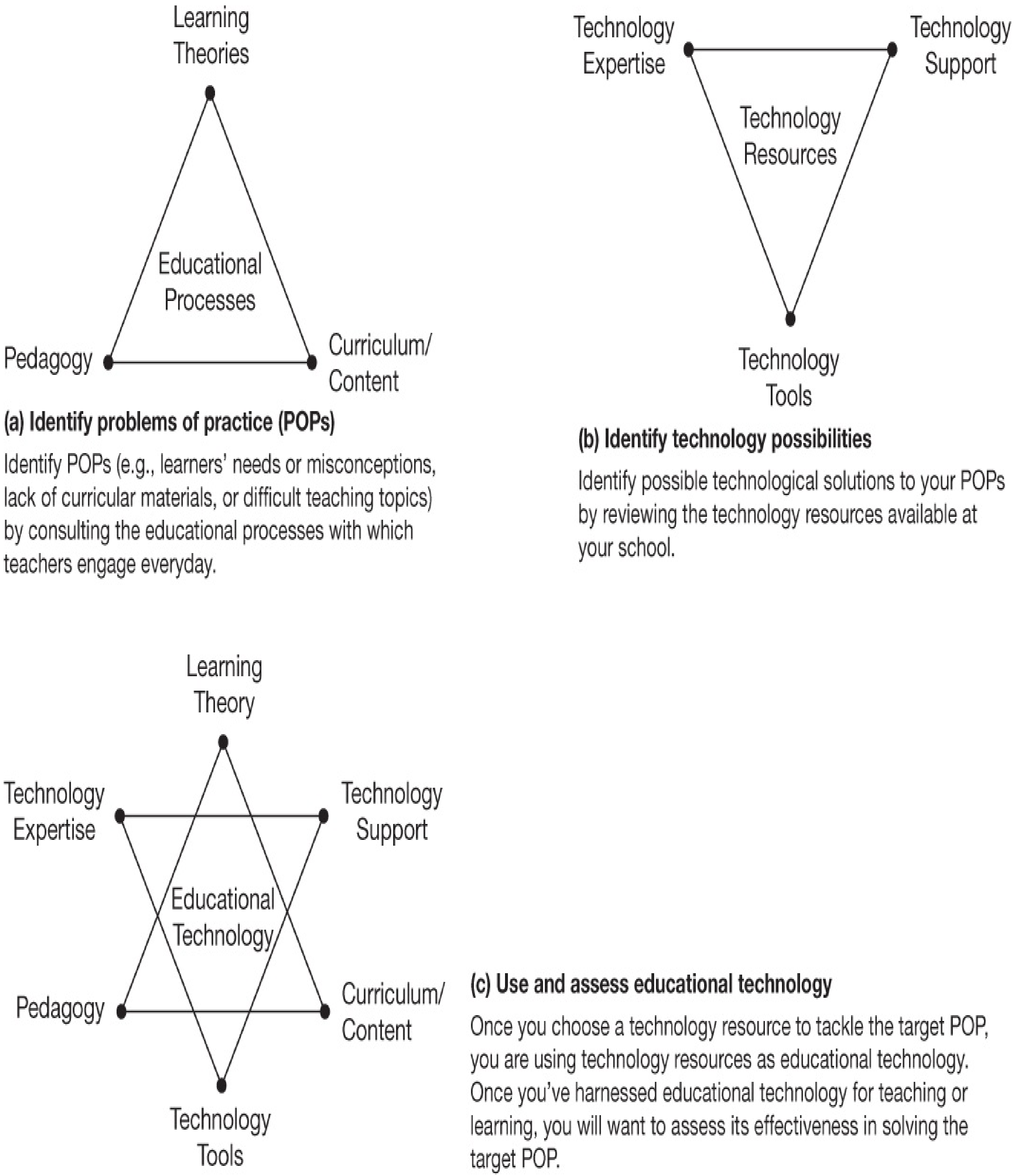


Figure 1.1 A Framework for Integrating Educational Technology

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.

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.

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

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

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.

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 startup 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.

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**.

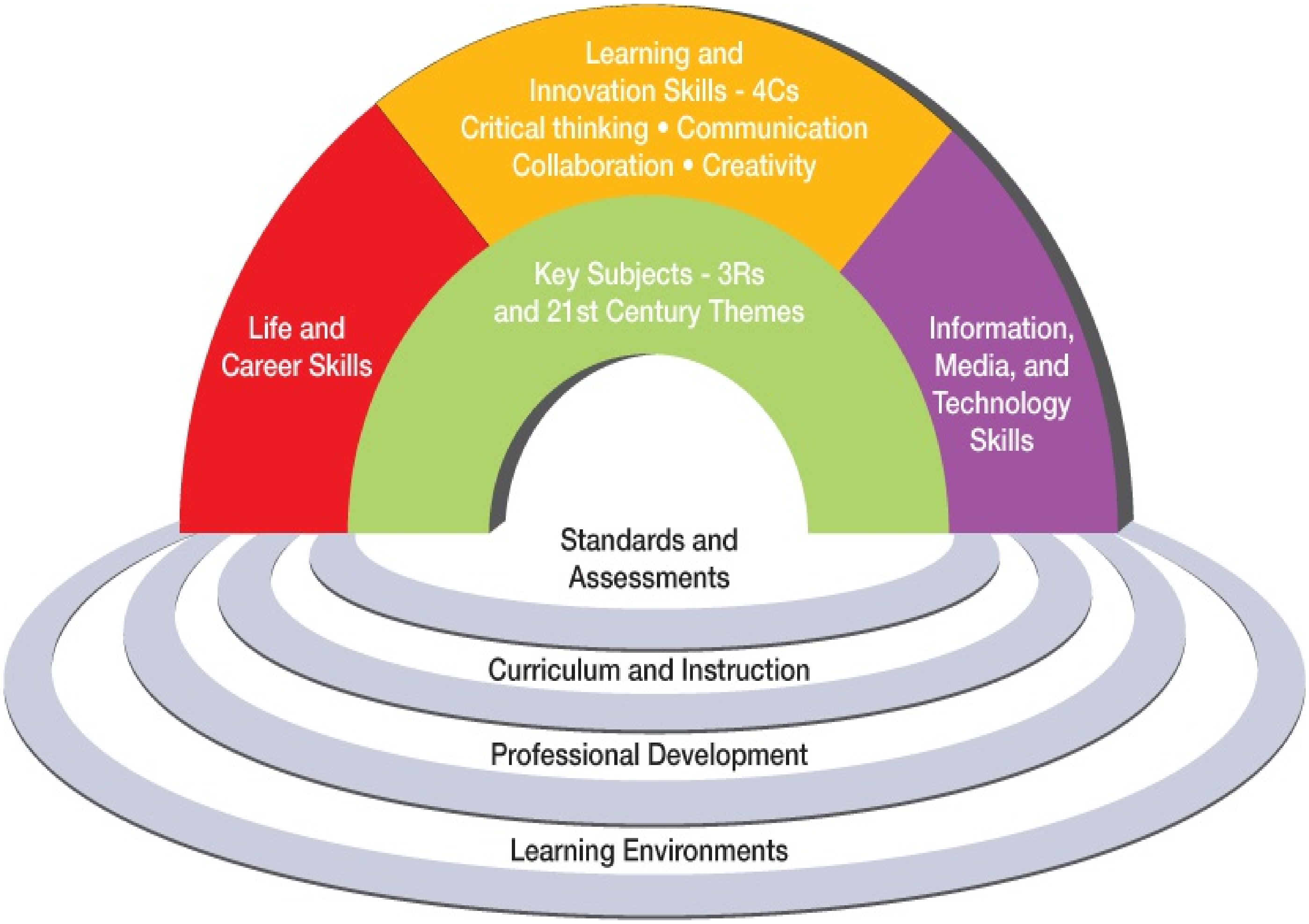


Figure 1.3 The P21 Skill Framework for 21st Century Learning

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

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 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 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.

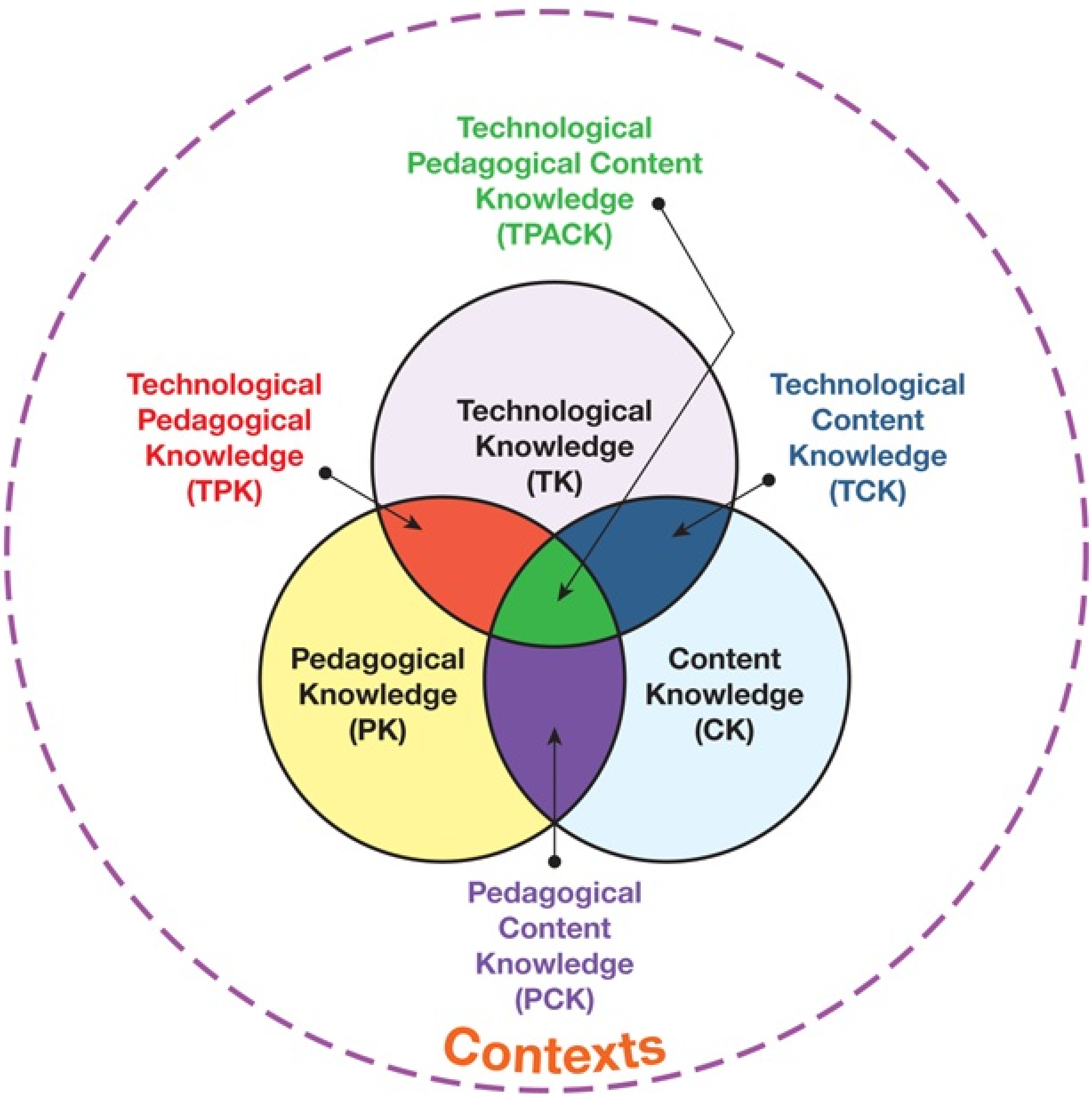


Figure 1.4 TPCK/TPACK Framework

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.

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.

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**.

Table 1.2 Conditions That Shape the Environment for Using Technology

Conditions	Implications for Educators and Students
Educational	
Technology leadership and vision Digital literacy/digital citizenship needs Optimal technology-based pedagogy	• 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

Online learning opportunities	
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

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 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 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.

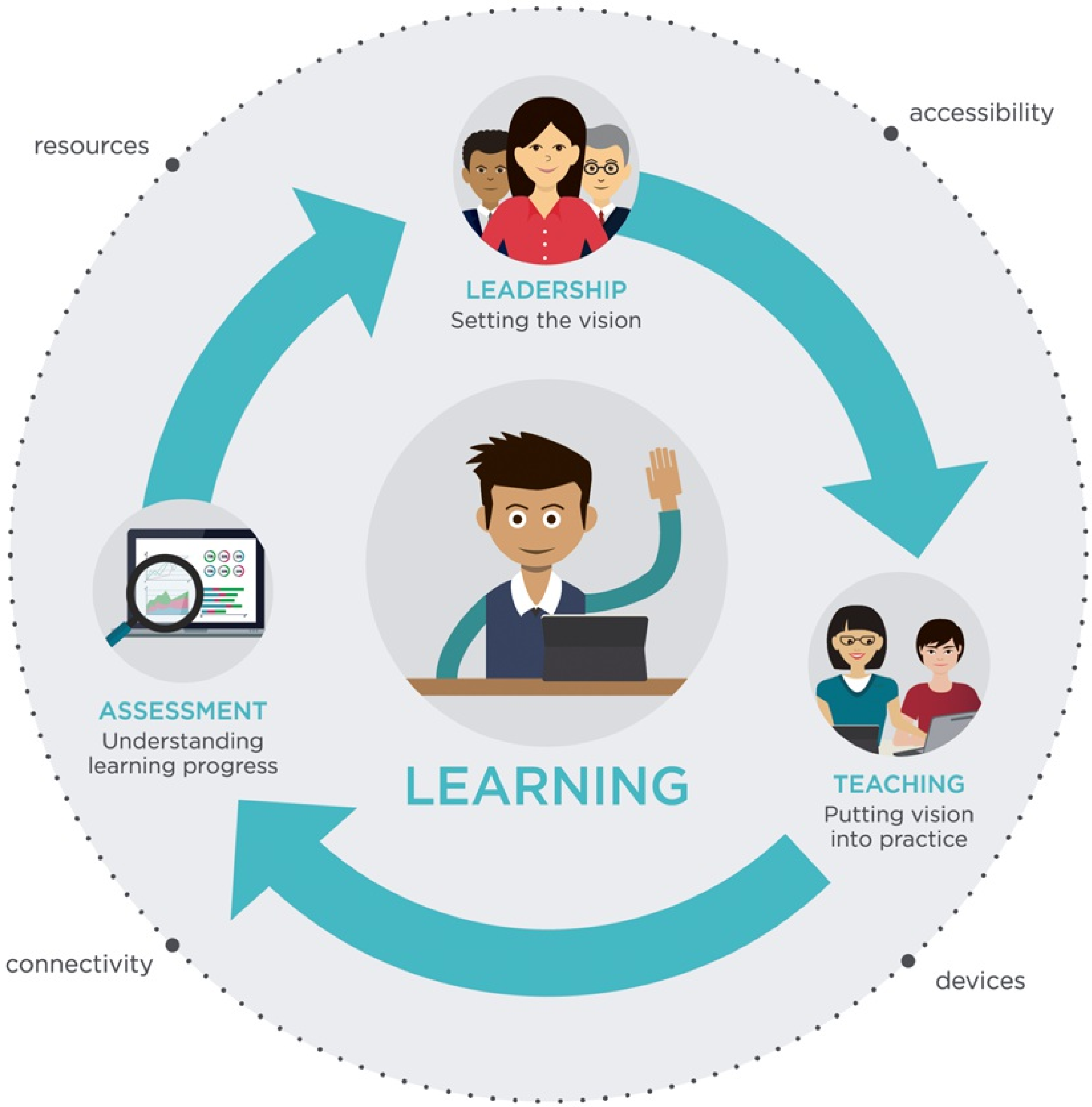
Political Conditions

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 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.

FITTING THE PIECES TOGETHER



INFRASTRUCTURE

Providing accessibility, resources and connectivity so that learning is **everywhere, all the time**

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.

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.

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.

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.

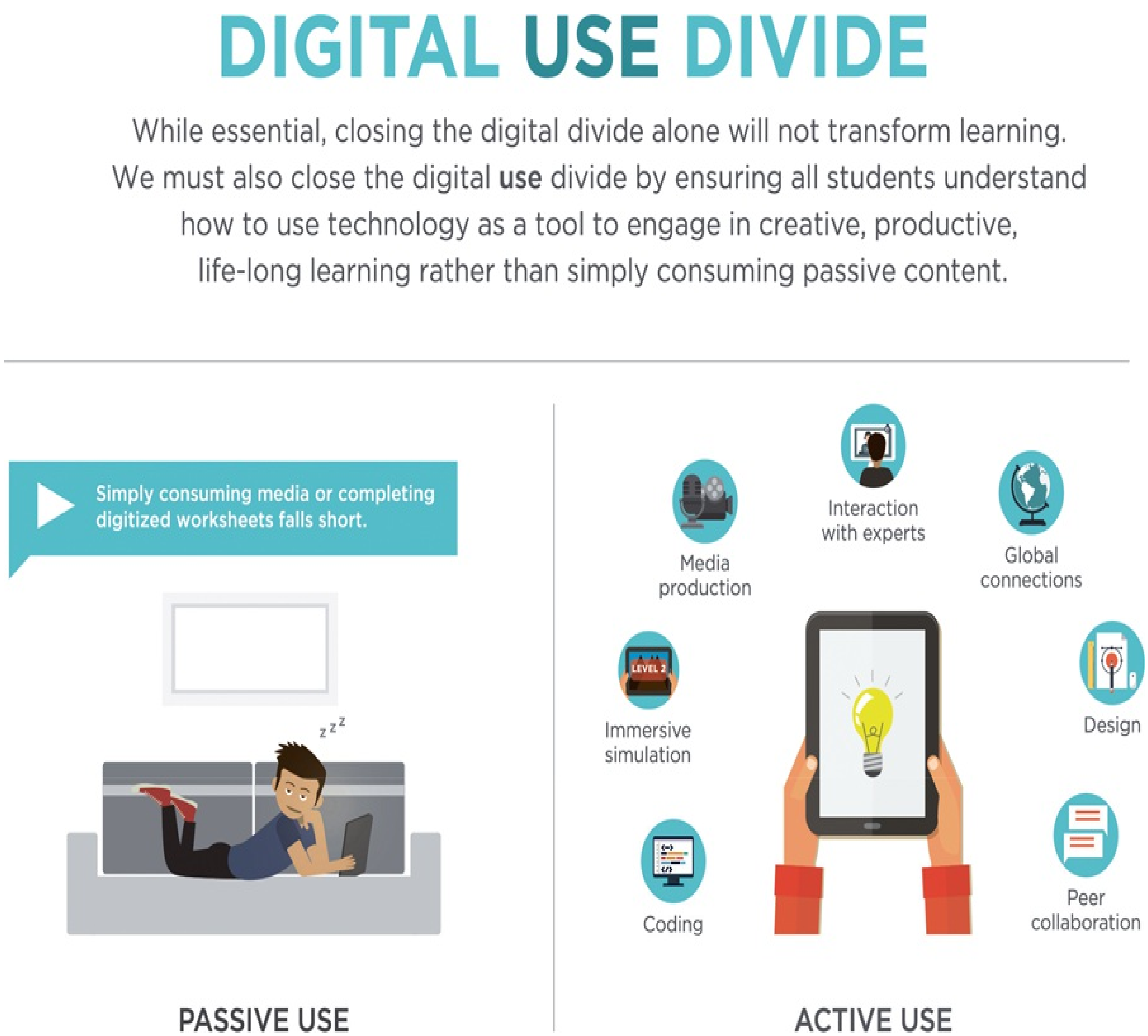


Figure 1.6 Digital Divide Infographic

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/

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

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

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 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. 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 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.

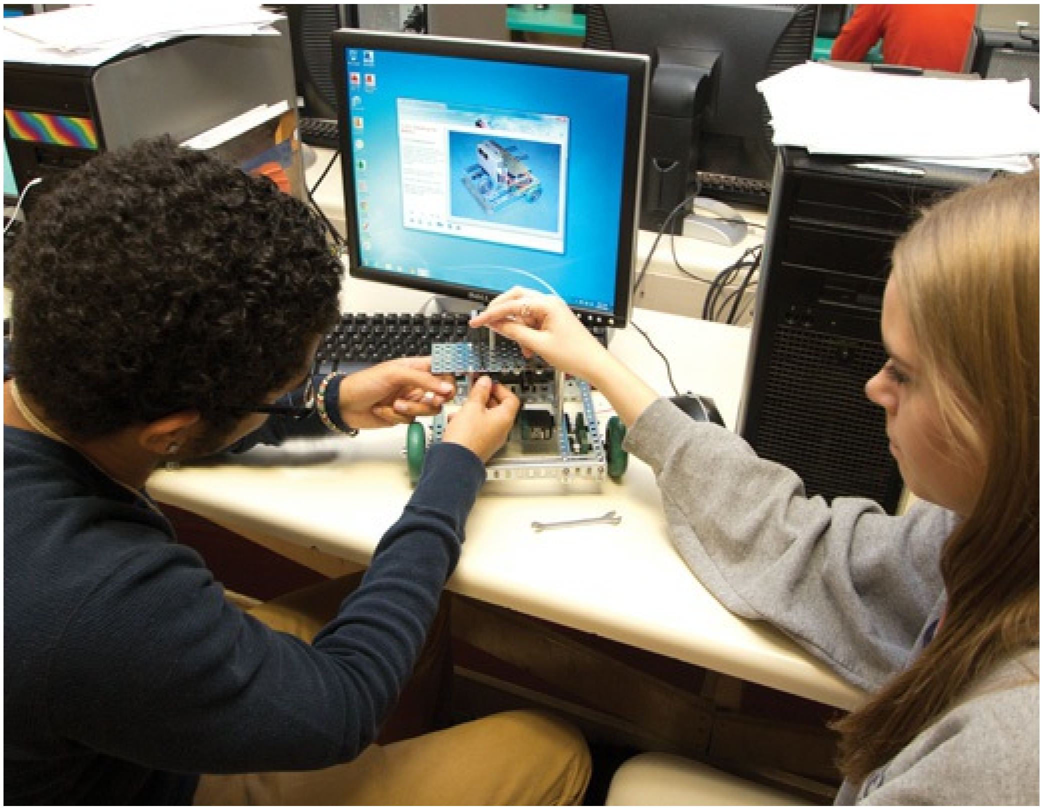


Figure 1.7 Girls and boys learning through robotics

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.

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**).

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?

Chapter 2 Theory into Practice

FOUNDATIONS FOR TRANSFORMATIVE TECHNOLOGY INTEGRATION

Learning Outcomes

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

2.1 Identify how the epistemologies of directed instruction and constructivist learning theory foundations and the Turn-Around Technology Integration Pedagogy And Planning (TTIPP) model contribute to transformative technology integration practices. (ISTE Standards for Educators: 1—Learner; 2—Leader; 5—Designer)

2.2 Identify the theorists and beliefs associated with directed instruction learning theories and how these theories contribute to technology integration strategies. (ISTE Standards for Educators: 1—Learner; 5—Designer)

2.3 Identify the theorists and beliefs associated with constructivist instruction learning theories and how these theories contribute to technology integration strategies. (ISTE Standards for Educators: 1—Learner; 5—Designer)

2.4 Contrast directed, constructivist, or combined technology integration strategies. (ISTE Standards for Educators: 1—Learner; 5—Designer)

2.5 Use steps in the Turn-around Technology Integration Pedagogy and Planning (TTIPP) model to determine planning needs for classroom technology integration. (ISTE Standards for Educators: 1—Learner; 2—Leader; 3—Citizen; 4—Collaborator; 5—Designer; 6—Facilitator; 7—Analyst)

TECHNOLOGY INTEGRATION IN ACTION:

The Role of Learning Theory

Strategy A: Preparing Students for State Tests

One of Mr. Ng's responsibilities as mathematics department chair was helping all teachers make sure their students did well on the mathematics portion of the state's Test of Essential Skills for Success (TESS-M). Mr. Ng and the other math teachers were determined that every student in the school would pass the TESS-M. They also decided that they would not just "teach to the test." They wanted the students to have a good grounding in math skills that would serve them well in their future education.

From practice test scores he had seen, Mr. Ng realized that too many students needed help to provide individual coaches or tutors for each one, and he disliked the idea of making all students work on skills only some of them needed. At a school he had visited in another district, Mr.

Ng was impressed with how teachers relied on a computer-based system that included drills, tutorials, simulations, and problem-solving activities that they could access in their classrooms and the computer lab.

One of the benefits of the system was that students could solve math problems and teachers could get a list of skills with which each student was having trouble. Then the system would recommend specific activities, on and off the system, matched to each child's needs. The activities ranged from practice in very basic math skills to solving real-life problems that required algebra and other math skills. Mr. Ng persuaded his principal to purchase a year's subscription to this system, and he and the other math teachers agreed on ways they would use it to support their classroom instruction.

That year, almost every student at the school passed the TESS-M. The math teachers agreed that the computer-based activities had played a key role in students' preparation. They liked the way those activities helped target students' specific needs more efficiently without overemphasizing test taking. Mr. Ng asked the principal to make the system a permanent part of the school's budget.

Strategy B: A Simulated Family Project

Ms. Rodriguez's middle-school math students are usually fairly good at mathematics skills, although based on various practice tests, some would have trouble passing the mathematics portion of state's Test of Essential Skills for Success (TESS-M). Ms. Rodriguez liked to do at least one ongoing project each year to show students how their math skills apply to real-life situations. She also wanted them to learn to work together to solve problems just as they would be doing in high school and college and in work situations when they graduate.

The first activity she implemented at the beginning of each year was to have her students work in small groups to simulate “families.” They selected a type of “job” for their “wage earner” and created a monthly budget in a spreadsheet template she designed to show income earned from the imaginary job and estimated monthly expenses for each of them and for the “family.” To select jobs, the groups consulted online newspaper Help Wanted sections, websites for job seekers, and adults they knew to get an idea of what positions were available and how much they paid.

To estimate expenses, they researched online newspaper and real estate ads to see how much it cost to rent a house or an apartment in an area where their “family” would live. Throughout the year, she gave each group unexpected expenses (e.g., the dog gets sick, the roof is leaking); the students then adjusted their spreadsheet budget to compensate for the extra expenses. If a group either had a surplus or went into debt, she made the students consider a range of investments, loans, relocating, or selling assets, which they did by researching available interest rates and prices and adding their choices to their spreadsheet budgets.

Toward the end of the year, Ms. Rodriguez had students calculate estimated taxes on their earnings. Finally, they prepared a report using presentation software that showed charts of their spending and what they learned about “making ends meet.” The students always told her this was the most meaningful math activity they had ever done.

Introduction

This chapter introduces two essential ingredients of a vision for how technologies work in instruction. These are learning theory foundations and a technology integration planning model. Learning theories have contributed to the use of two instructional strategies—directed and constructivist—that influence teachers' approaches to technology integration. We take our directed teaching models from learning theorists such as B. F. Skinner, Richard Atkinson and Richard Shiffrin, Robert Gagne, and systems theorists such as Robert Mager, Leslie Briggs, and Lee Cronbach. Our constructivist strategies are based on the work of theorists such as John Dewey, Albert Bandura, Lev Vygotsky, Jean Piaget, Jerome Bruner, and Howard Gardner. You will read about the contributions of these education giants. You'll also read how teachers can use the Turn-around Technology Integration Pedagogy and Planning (TTIPP) model to plan technology integration.

Overview of Successful Technology Integration Planning and Practice

The answer to the question “Which kind of technology integration strategy works best?” is “It depends on the situation.” Effective technology integration calls for a well-planned match of learning needs with technology resources. This section introduces how learning theories and a thorough technology integration planning model work in combination to enable transformative technology integration pedagogy.

Learning Theory Foundations

To use all the insights we have gained from the study and research on how people acquire new knowledge, learning theories should inform teaching strategies. Thus, it is important to begin with a look at two very different theories of how learning occurs and examine how various kinds of technology integration strategies can be derived from them.

Two Perspectives on Instruction

Theorists and practitioners reflect two contrasting views of how instruction and learning should take place:

- **Directed instruction**—Teachers should transmit a predefined set of information to students through teacher-organized activities. This view is based on **objectivism**, a belief system grounded primarily in behaviorist learning theory and the information-processing branch of the cognitive learning theories.

- **Constructivist-based instruction**—Teachers should build inquiry, discovery, and experiential learning into their instruction so that learners can generate their own knowledge through experiences while teachers serve as facilitators. This view is based on **constructivism**, which evolved from other branches of thinking in cognitive learning theory.

A few technology applications, such as drill and practice and tutorial software functions, are associated only with directed instruction; most others (problem solving, multimedia production, web-based learning) can be implemented in either directed or constructivist ways, depending on how they are used. There are meaningful roles for both **directed instruction** and **constructivist learning** strategies and the technology applications associated with them. Both can help teachers and students meet the many and varied requirements of learning in today's knowledge society.

Origins of These Instructional Perspectives

Both people who espouse directed instruction methods and those who use constructivist approaches are attempting to identify what **Gagné (1985)** called the conditions of learning, or sets of circumstances that bring about learning. Both directed instruction and constructivist-based instruction approaches are based on the work of respected learning theorists and psychologists who have studied both the behavior of human beings as learning organisms and the behavior of students in schools and classrooms.

Educators' views diverge, however, in the ways they define learning, how they identify the conditions required to make learning happen, and how they perceive the problems that interfere most with learning. They disagree because the two perspectives have very different underlying **epistemologies**, the beliefs about the nature of human knowledge and how to develop it. **Constructivists and objectivists** come from separate and different **epistemologies**. These philosophical differences can be briefly summarized in the following way:

Objectivists—Knowledge has a separate, real existence of its own outside the human mind. Learning happens when this knowledge is transmitted to people who store it in their minds in ways that they can be retrieve later.

Constructivists—Humans construct all knowledge in their minds by participating in experiences. Learning occurs when someone constructs both mechanisms for learning and that person's own unique version of the knowledge informed by background, experiences, and aptitudes.

Sfard (1998) found that objectivists and constructivists view learning in such different ways that they actually use different metaphors for it: the acquisition metaphor and the participation metaphor. These differences in language signal fundamental differences in thinking about how learning takes place and how we can foster it.

Sometimes differences of opinion among objectivists and constructivists have generated strident debate in the literature (**Clark, Yates, Early, & Moulton, 2009**; **Baroody, Eiland, Purpura, & Reid, 2013**). Objectivists say constructivist methods are unrealistic; constructivists consider directed methods to be too restrictive. The following sections describe learning theories that underlie these belief systems. Subsequent sections discuss how these theories can inform different technology integration strategies.

Turn-around Technology Integration Pedagogy and Planning (TTIPP) Model

For the procedural and "people" issues involved in technology integration, we look to the steps of the three-phased **Turn-around Technology Integration Pedagogy and Planning (TTIPP)** model to plan and implement technology-based lessons. This planning model includes three phases that lead teachers to (1) analyze problems of practice, assess teaching/learning needs/assets, and identify possible technology solutions, (2) design the lesson's objectives, assessments, and instructional and learning strategies; identify the relative advantage; and implement the lesson, and (3) analyze and revise the technology-supported instruction and share outcomes with peer teachers.

The TTIPP model privileges the concept of **turn-around pedagogy** (**Kamler & Comber, 2005**), which is instruction that revitalizes students' interest and engagement in learning the curriculum. Teachers turn toward students by becoming more informed about their background, knowledge, experiences, and interests and by developing asset versus deficit views of the learners. Teachers revitalize their curriculum through new pedagogy that literally turns students around from disengagement to re-engagement, which leads to higher achievement.

Another significant feature of the TTIPP model is that it helps teachers evaluate (or **RATify**) their proposed and/or adopted technology-based lessons for their potential to transform teaching, learning, and curriculum using the **Replacement, Amplification, Transformation (RAT)** assessment framework. By RATifying lessons, a teacher will be able to identify exactly how the technology contributes to specific aspects of instruction, learning, and/or curriculum.

The teaching practice and research that originated turn-around pedagogy was accomplished when small groups of teachers inquired into their teaching over a 3-year period (**Kamler & Comber, 2005**). An individual teacher can implement the TTIPP model alone, but we encourage its use by teachers in collaboration with others, such as media specialists or peer teachers.

Learning Theory Foundations of Directed Integration Models

Directed models of integrating technology were derived primarily from a combination of four theorists and theories—behaviorist, information-processing, cognitive-behaviorist, and instructional design theories—each of which contributes essential qualities and procedures and the **systems approaches to instructional design** that were based on them. This section summarizes the basic concepts associated with these theories and their implications for education practices and technology integration.

Behaviorist Theories

These theories, among the earliest explanations for how people learn new things, are based primarily on the work of B. F. Skinner (1904–1990). Before Skinner, theories of learning were dominated by **classical conditioning** concepts proposed by Russian physiologist Ivan Pavlov, who proposed that behavior is largely controlled by involuntary physical responses to outside stimuli (e.g., dogs salivating at the sight of a can of dog food). By contrast, Skinner's **operant conditioning** theory asserted that people can have voluntary mental control over their responses (e.g., a child reasons that he will be praised if he behaves well in school). Skinner's work showed that observable behaviors are controlled by the consequences of actions rather than by events that precede the actions. A consequence is an outcome (stimulus) after the behavior, which can influence future behaviors. Skinner's work made him a highly influential figure in education.

Skinner reasoned that the internal processes inside the mind involved in learning could not be seen directly. Scientific work had not advanced sufficiently at that time to observe brain activity. Therefore, he concentrated on cause-and-effect relationships that could be established by observation. He found that human behavior could be shaped by **contingencies of reinforcement** or situations in which reinforcement for a learner is contingent on a desired response. He identified three kinds of situations that can shape behavior:

- **Positive reinforcement**—A situation is set up so that an increase in a desired behavior will result from a stimulus. For example, to earn praise or good grades (positive reinforcement), a learner studies hard for a test more often (desired behavior).
- **Negative reinforcement**—A situation is set up so that an increase in a desired behavior will result from avoiding or removing a stimulus. For example, a student dislikes going to detention (negative reinforcement), so to avoid detention again, she is quiet in class more often (desired behavior).
- **Punishment**—A situation is set up so that a decrease in a desired behavior will result from undesirable consequences, such as when a student is given a failing grade (punishment) when he cheats on a test (undesirable behavior), so he is less likely to cheat in the future.

Implications of Behaviorist Theories for Education

Skinner's influential book, The Technology of Teaching (1968), presented a detailed theory of how classroom instruction should reflect these behaviorist principles. Many of his classroom management and instructional techniques still are widely used today. Skinner believed that teaching is a process of arranging contingencies of reinforcement effectively to bring about learning. He believed that even such high-level capabilities as critical thinking and creativity could be taught in this way; doing so was simply a matter of establishing chains of behavior through principles of reinforcement. Skinner felt that **programmed instruction** was the most efficient means available for learning skills. Educational psychologists such as Benjamin Bloom also used Skinner's principles to develop what became known as mastery learning:

- We know when people learn only by observing changes in their behavior.
- Behavior is shaped by stimulus-response connections.
- Reinforcement strengthens responses; if people do something and are reinforced for it, they learn to respond in predictable ways.
- Chains of behavior become skills.

Implications of Behaviorist Theories for Technology Integration

Most original drill and practice software was based on Skinner's reinforcement principles such as when students knew they would receive praise or an entertaining graphic if they gave correct answers. Much tutorial software is based on the idea of programmed instruction. Because the idea behind drill and practice software is to increase the frequency of correct answering in response to stimuli, these packages often are used to help students memorize important basic information whereas tutorial software gives students an efficient path through concepts they want to learn.

Information-Processing Theories

Educators found Skinner’s stimulus-response view of learned behavior insufficient to guide all types of learning, so during the 1950s and 1960s, the first cognitive (as opposed to behavioral) learning theorists began to hypothesize about processes inside the brain that allow human beings to learn and remember but could not be observed directly.

Although no single, cohesive information-processing theory of learning summarizes the field, the work of the information-processing theorists is based on a model of memory and storage originally proposed by **Atkinson and Shiffrin (1968)**: The brain contains certain structures that process information much like a computer. This model of the mind as computer hypothesizes that the human brain has three kinds of memory or “stores” as represented in **Figure 2.1**:

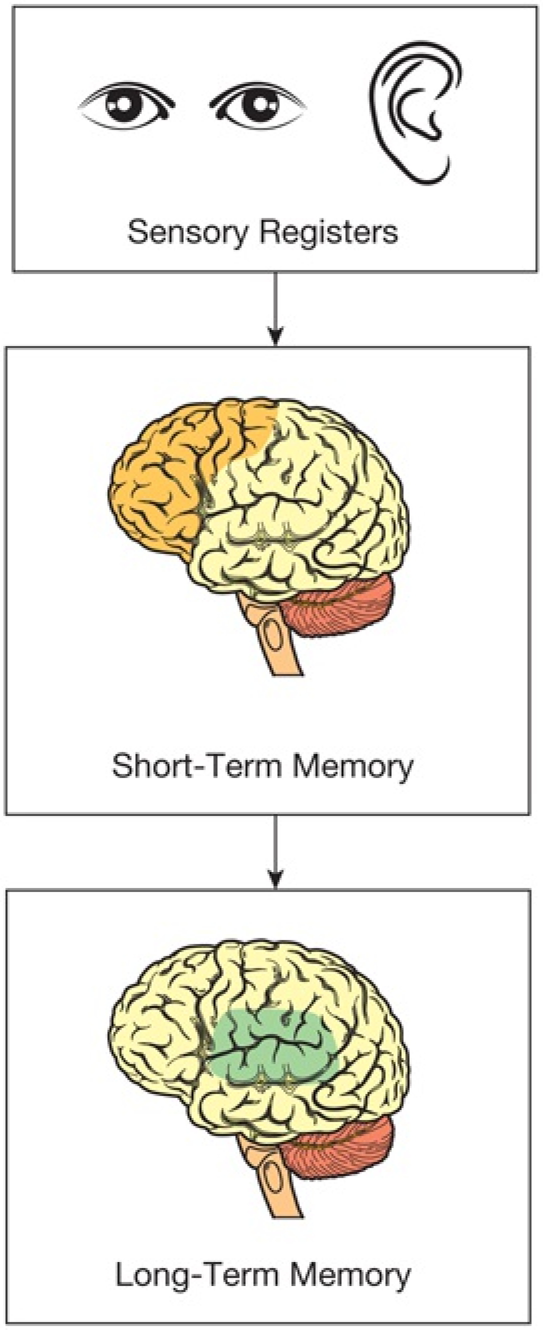


Figure 2.1 Three kinds of memory

- **Sensory registers**—This is the part of memory that receives all the information a person senses.
- **Short-term memory (STM)**—Also known as working memory, this is the part of memory where new information is held temporarily until it is either lost or placed into long-term memory.

- **Long-term memory (LTM)** —This is the part of memory that has an unlimited capacity and can hold information indefinitely.

According to the model of memory and storage, learning begins when information is sensed through receptors: eyes, ears, nose, mouth, and/or hands. This information is held in the sensory registers for a very short time (perhaps a second) after which it either enters STM or is lost. Many information-processing theorists believed that information could be sensed but lost before it gets to STM if the person is not paying attention to it. According to these theorists, anything that people pay attention to goes into working memory where it can stay for about 5 to 20 seconds. After this time, if information is not processed or practiced in a way that causes it to transfer to LTM, then it, too, is lost. Information-processing theorists believed that for new information to be transferred to LTM, it must be linked in some way to prior knowledge already in LTM. Once information does enter LTM, it is there essentially permanently, although some psychologists believed that even information stored in LTM can be lost if not used regularly.

Implications of Information-Processing Theories for Education

Although subsequent studies have indicated that learning could be more complicated than this model of memory would explain (**Schunk, 2012**), information-processing views have become the basis for many common classroom practices. Teaching practices based on these concepts include the use of:

1. Interesting questions and eye-catching material to help students pay attention to a new topic, such as a photographs or graphs

2. Mnemonic devices, such as remembering that HOMES stands for the first letters of the five Great Lakes: Huron, Ontario, Michigan, Erie, Superior
3. Instructions that point out (or cue) important points in new material to help students remember, such as linking them to information they already know
4. Visual explanations of abstract concepts, such as from virtual manipulatives or simulations
5. Practice exercises to help transfer information from STM to LTM, such as drill and practice or tutorials

Implications of Information-Processing Theories for Technology Integration

Computer programs provide ideal environments for the highly structured cueing, attention-getting, visualization, and practice features that information-processing theorists found so essential to learning and remembering. Information-processing theories have also guided the development of **artificial intelligence (AI)** applications, an attempt to develop computer software that can simulate the thinking and learning behaviors of humans. Much of the drill and practice functions within learning software available is designed to help students encode and store newly learned information into LTM.

Cognitive-Behaviorist Theory

Robert Gagné (1916–2002) was a renowned educational psychologist who translated principles from behaviorist and information-processing theories into practical instructional strategies that teachers could employ with directed instruction. He is best known for three of his contributions in this area: Events of Instruction, types of learning, and learning hierarchies. Gagné used the information-processing model of internal processes to derive a set of guidelines that teachers could follow to arrange optimal “conditions of learning.” His set of **Nine Events of Instruction** was perhaps the best known of these guidelines (**Gagné, Briggs, & Wager, 1992**):

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting new material
5. Providing learning guidance
6. Eliciting performance
7. Providing feedback about correctness
8. Assessing performance
9. Enhancing retention and recall

Gagné identified several types of learning as behaviors that students demonstrate after acquiring knowledge. These differ according to the conditions necessary to foster them. He showed how the Events of Instruction would be carried out slightly differently for the five domains of learning outcomes (**Gagné et al., 1992**):

1. Intellectual skills:
   - Problem solving
   - Higher order rules
   - Defined concepts
   - Concrete concepts
   - Discriminations

2. Cognitive strategies

3. Verbal information
4. Motor skills
5. Attitudes

The development of “intellectual skills,” Gagné believed, requires learning that is akin to a building process. Lower level skills provide a necessary foundation for higher level ones. For example, to learn to solve long division problems, students first would have to learn all the prerequisite math skills, beginning with number recognition, number facts, simple addition and subtraction, multiplication, and simple division. Therefore, to teach a skill, a teacher must first identify its prerequisite skills and make sure students possess them. He called this list of building block skills a **learning hierarchy**.

Implications of Cognitive-Behaviorist Theory for Education

Instruction based on this theory provides “conditions for learning” by offering activities matched to each type of skill. Students had to demonstrate that they had learned prerequisite skills by demonstrating the type of behavior appropriate for the skill. For example, if the skill was using a grammar rule, students had to demonstrate that they could correctly apply the rule in situations that required it. Gagné’s Events of Instruction and learning hierarchies have been widely used to develop systematic instructional design principles. Although his work has had more impact on designing instruction for business, industry, and the military than for K–12 schools, many school curriculum development projects still use a learning hierarchy approach to sequencing skills.

Implications of Cognitive-Behaviorist Theory for

Technology Integration

Computer-based methods such as drills and tutorials were deemed useful because they could consistently provide the ideal events and conditions for learning. **Gagné, Wager, and Rojas (1981)** showed how Gagné's Events of Instruction could be used to plan lessons using each kind of instructional software function (drill, tutorial, simulation). These authors said that only a tutorial could "stand by itself" and accomplish all of the necessary events of instruction; the other kinds of software required teacher-led activities to accomplish events before and after software use.

Systems Approaches: Instructional Design Models

There are many versions of the systematic design process and many views on what constitutes instructional design (**Roblyer, 2015**). **Saettler (1990)** proposed that instructional systems developed scientifically precede the 21st century but pointed out that modern instructional design models and methods have their roots in the collaborative work of Robert Gagné and Leslie Briggs. These notable educational psychologists developed a way to transfer "laboratory-based learning principles" gleaned from military and industrial training to create an efficient way to develop curriculum and instruction for schools.

Gagné specialized in the use of instructional task analysis to identify required subskills and conditions of learning for them. Briggs' expertise was in systematic methods of designing training programs to save companies time and money in training their personnel. When Gagné and Briggs combined their two areas of expertise, the result was a set of step-by-step processes known as a **systems approach to instructional design** or systematic instructional design, which came into common use in the 1970s and 1980s. Designers created an instructional system by stating goals and objectives; analyzing a task to decide on learning conditions; aligning assessment and instructional strategies with goals and objectives; creating materials that deliver strategies; and testing and revising materials before finalizing them.

Theorists and ideas associated with the development of instructional design process include Mager (instructional objectives), Glaser (criterion-referenced testing), and Cronbach and Scriven (formative and summative evaluation). Other major contributors to modern instructional design models include Merrill (component display theory) and Reigeluth (elaboration theory).

Implications of Systems Approaches for Education

Systems approaches to designing instruction have had great influence on training programs for business, industry, and the military but somewhat less on K–12 education. However, performance objectives and sequences for instructional activities still are widely used. Most lesson planning models call for performance objectives (sometimes called behavioral objectives) to be stated in terms of measurable, observable learner behaviors.

Implications of Systems Approaches for Technology Integration

Most directed models for using technology resources are based on systems approaches; that is, teachers set objectives for a lesson and then develop a sequence of activities. A software package or a web activity is selected to carry out part of the instructional sequence. For example, the teacher could introduce a principle of genetics and then allow students to experiment with an online simulation to “breed” cats to see the principle in action. To those who espouse this approach, a system of instruction must be structured and sequential and continually monitor student progress. Computer-based instruction is well suited to delivering such an instructional system in a consistent and reliable way while monitoring and giving fast feedback on student progress.

Objectivist Theory Foundations for Directed Methods

Figure 2.2 shows how these four theories contribute to directed technology integration strategies based on mastery learning approaches, or sequences of objectives that, once met, define mastery of a subject. A considerable body of research indicates that directed methods work well to foster this kind of approach. For example, **Clark, Yates, Early, and Moulton (2010)** argue that directed instruction is more effective and efficient than minimally guided instruction when learners do not have enough prior knowledge to be self-guided. They say that minimally guided instruction ignores the fundamentals of human cognition and overloads working memory. **Adams, Mayer, MacNamara, Koenig, and Wainess (2012)** and other scholars have echoed **Hirsch’s (2002)** early declaration that “one minute of explicit (directed) learning can be more effective than a month of implicit (exploratory) learning.”

Figure 2.2 Theoretical Foundations for Directed Technology Integration Strategies

Objectivists focus primarily on technology integration strategies for systematically designed, structured learning products, such as drills, tutorials, and adaptive or personalized learning systems. When they do use other materials such as simulations and some kinds of problem-solving software that have no innate structure, integration strategies are very structured, providing a step-by-step sequence of learning activities matched to specific performance objectives. When objectivists evaluate these products, they typically look for a match among objectives, methods, and assessment strategies and how well they help teachers and students meet curriculum standards. To reflect objectivist principles, materials and integration strategies must have clearly defined objectives and a set sequence for their use.

Learning Theory Foundations of Constructivist Integration Models

Constructivist beliefs and methods were derived from a combination of six theorists and theories, each of which contributed essential qualities and procedures: social activism theory, social cognitive theory, scaffolding theory, child development theory, discovery learning and child development, and multiple intelligences theory. This section summarizes the basic concepts associated with each of these theories and their implications for education practices and for technology integration.

Social Activism Theory

John Dewey (1859-1952) is considered a philosopher and an educational writer. Most of his contributions to education predated those of the learning theorists described previously. Yet no one voice in education has had more pervasive and continuing influence on educational practice. In many ways, he can be thought of as the Grandfather of Constructivism, but he also advocated merging absolutism and experimentalism in much the same way as this chapter acknowledges using a combination of directed and constructivist methods.

Dewey's beliefs were very much shaped by his direct involvement in the social and cultural issues of the time. As an early proponent of racial equality and women's suffrage, he was a radical in his political views and helped found a third American political party for liberals. His beliefs about education reflected this radical activism. Although he did not originate the Progressive Education Movement, a reform initiative popular in the first half of the 1900s, Dewey was identified closely with it; the movement survived his death in 1952 by only a few years. His philosophy of education, which he was able to see implemented at the turn of the century in a laboratory school established at the University of Chicago, focused on principles and concepts in direct opposition to those in education during that period. He believed the following:

- **Curricula should arise from students' interests**—Dewey deplored standardization. He felt curriculum should be flexible and tailored to the needs of each student, a "pedocentric" strategy where the children are central rather than the "scholiocentric" where the institution is central. He advocated letting each child's experiences determine individual learning activities.
- **Curricula topics should be integrated rather than isolated from each other**—Dewey felt that isolating topics from one another prevented learners from grasping the whole of knowledge and caused skills and facts to be viewed as unrelated bits of information.
- **Education is growth rather than an end in itself**—Dewey did not share the common view of the time that education is preparation for work. He found that this view served to separate society into social classes and promote elitism. Rather, he looked on education as a way of helping individuals understand their culture and develop their relationship to society and their unique roles in it.
- **Education occurs through its connection with life rather than through participation in curriculum**—Dewey felt that social consciousness was the ultimate aim of all education. To be useful, all learning had to be in the context of social experience. However, he found that school skills such as reading and mathematics were becoming ends in themselves, disconnected from any meaningful social context.
- **Learning should be hands on and experience based rather than**

> **abstract**—Dewey objected to commonly used teaching methods characterized by teacher-to-student communication channels and prioritized memorization and recall. He believed that meaningful learning resulted from students working cooperatively on tasks that were directly related to their interests. Dewey's writings (e.g., The School and Society, 1899; The Child and the Curriculum, 1902; How We Think, 1910; Schools of Tomorrow, 1915; Democracy and Education, 1916; Experience and Education, 1938) spanned an era of monumental change in America's cultural identity and helped reform the country's education system to reflect those changing times.

Implications of Social Activism for Education

Today's interdisciplinary curriculum and hands-on, experience-based learning are very much in tune with Dewey's lifelong message. However, it also is likely that he would deplore the current standards movement and the use of testing programs to determine school promotion and readiness for graduation.

Implications of Social Activism for Technology Integration

Dewey would likely have approved of technologies such as use of the web to help students communicate with each other and learn more about their society (**Bruce, 2000**). Dewey's emphasis on the need for cooperative learning would mesh well with technologies used for developing group projects and presentations. However, as Dewey himself recognized, the central problem with all these resources is combining them into a curriculum that encourages intellectual challenge.

Social Cognitive Theory

The work of Albert Bandura (1925–) challenged some of the major premises of conditioning theories that were most popular at that time. He said that contrary to the behavioral theories of reinforcement, students learned a great deal through observation (which he called **vicarious learning**) rather than through their actions (which he called **enactive learning**) (**Schunk, 2012**). Bandura found, for example, that one of the most powerful ways students learned was by observing the behaviors modeled by those around them.

Bandura also found there was a difference between learning and behaviors that showed learning. Learning was acquiring new information or concepts, but he found that students often learned information and concepts in social settings that they did not reflect in any immediate behavior. Although he acknowledged that enactive learning was learning from one's own actions, his ideas differed from Skinner's view that behavior changed automatically (i.e., without intention) as a result of reinforcement. Instead, Bandura found that students' beliefs and judgments as social beings determined whether or not their actions changed; their internal cognitive processes shaped their actions rather than being solely a result of external consequences resulting from reinforcement.

Motivation to learn also played a central role in Bandura's social cognitive theory. He found that students who were innately capable sometimes did not learn because they lacked **self-efficacy**, or the belief in their abilities to accomplish the actions necessary to learn. Self-efficacy beliefs can be shaped by teachers and others and can affect whether students even try to learn as well as how long they persist at learning tasks. **Schunk (2012)** reported a series of studies showing that students' self-efficacy and achievement increased from watching videos of their own or peers' performance. Self-efficacy differs from self-concept in that self-concept is a general self-perception of one's overall abilities; self-efficacy is a belief specific to a certain area of learning.

Implications of Social Cognitive Theory for Education

Educators' practices acknowledge the importance of modeling. They frequently try to shape student behaviors and grow motivation to learn by showing other students of similar age and backgrounds exhibiting these behaviors. Teachers also provide models, though sometimes inadvertently. Students tend to imitate what teachers do rather than attending to what teachers say.

Implications of Social Cognitive Theory for Technology Integration

Video examples can provide many examples of models that teachers would not otherwise have at their disposal. In addition, studies have shown that self-modeling videos in which students watch examples of their own successful performance can increase their self-efficacy in the area.

Scaffolding Theories

Lev Semenovich Vygotsky (1896–1934) was a Russian philosopher and educational psychologist whose ideas had more influence on the development of educational theory and practice in America than in his own country (**Davydov, 1995**). Vygotsky felt that cognitive development was directly related to and based on social development (**Eggen & Kauchak, 2016**). What children learn and how they think are derived directly from the culture around them. Children learn by **scaffolding**, or building what they need to know on what they know with the help of adults. An adult perceives things much differently than a child does, but this difference decreases as children gradually translate their social views into personal, psychological ones. Vygotsky's theories with their emphasis on individual differences, personal creativity, and the influence of culture on learning were discordant with the socialist state of the USSR.

Vygotsky referred to the difference between these two levels of cognitive functioning (adult/expert and child/novice) as the **zone of proximal development (ZPD)**. He felt that teachers could provide good instruction by finding out where each child was in his or her development and building on the child's experiences. He called this building process "scaffolding." **Ormrod (2014)** stated that teachers promote students' cognitive development by presenting some classroom tasks that "they can complete only with assistance, that is, within each student's zone of proximal development" (p. **39**). Problems occur when the teacher leaves too much for the child to do independently, thus slowing the child's intellectual growth.

Implications of Scaffolding Theories for Education

Davydov (1995) found six basic implications for education from Vygotsky's ideas (p. **13**):

1. Education is intended to develop children's personalities.
2. The human personality is linked to its creative potential, and education should be designed to discover and develop this potential to its fullest in each individual.

3. Teaching and learning assume that students master their inner values through some personal activity.
4. Teachers direct and guide the individual activities of the students, but they do not force their will on them or dictate to them.
5. The most valuable methods for student learning are those that correspond to their individual developmental stages and needs; therefore, these methods cannot be uniform across students.
6. These ideas had heavy influence on constructivist thought; Vygotsky's works were very much in tune with constructivist concepts of instruction based on each child's personal experiences and learning through collaborative, social activities.

Implications of Scaffolding Theories for Technology Integration

Many constructivist models of technology use the concepts of scaffolding and developing each individual's potential. Many of the more visual tools, from Logo, a programming language designed to let young students solve design problems with an on-screen cursor or small robot called a "turtle," to virtual reality, are used under the assumption that they can help bring the student up from their level of understanding to a higher level by showing graphic examples and by giving them real-life experiences relevant to their individual needs.

Child Development Theory

French biologist Jean Piaget (1896–1980) explored early stages of development in children and the role of environment in these stages. Piaget's examination of how thinking and reasoning abilities develop in the human mind began with observations of his own children and developed into a career that spanned some 60 years. He referred to himself as a “genetic epistemologist,” or a scientist who studies how knowledge begins and develops in individuals. Both believers in and critics of Piagetian principles agree that his work was complex, profound, sometimes misunderstood, and usually oversimplified. However, at least two features of this work are widely recognized as underlying all of Piaget’s theories: his stages of cognitive development and his processes of cognitive functioning.

Piaget believed that all children go through four stages of cognitive development. Whereas the ages at which they experience these stages vary somewhat, he felt that each child developed higher reasoning abilities in the same sequence:

- **Sensorimotor stage** (from birth to about 2 years)—Children explore the world around them through their senses and through motor activity. In the earliest stage, they cannot differentiate between themselves and their environments (if they cannot see something, it does not exist). Also, they begin to have some perception of cause and effect; they develop the ability to follow something with their eyes.
- **Preoperational stage** (from about age 2 to about age 7)—Children develop greater abilities to communicate through speech and to engage in symbolic activities such as drawing objects and playing by pretending and imagining; develop numerical abilities such as the skill of assigning a number to each object in a group as it is counted; increase their level of self-control and are able to delay gratification but are still fairly egocentric; and are unable to do what Piaget called conservation tasks (tasks that call for recognizing that a substance remains the same even though its appearance changes; e.g., shape is not related to quantity).
- **Concrete operational stage** (from about age 7 to about age 11)—Children increase in abstract reasoning ability and ability to generalize from concrete

experiences and can do conservation tasks.
- **Formal operations stage** (from about age 12 to about age 15)—Children can form and test hypotheses, organize information, and reason scientifically; they can show results of abstract thinking in the form of symbolic materials (e.g., writing, drama).

Piaget believed a child's development from one stage to another was a gradual process of interacting with the environment. Children develop as they confront new and unfamiliar features of their environment that do not fit with their current views of the world. When this happens, a **disequilibrium** occurs that the child seeks to resolve through one of two processes of adaptation. The child either fits the new experiences into his or her existing view of the world (a process called **assimilation**) or changes that schema or view of the world to incorporate the new experiences (a process called **accommodation**). Although recent research has raised questions about the ages at which children's abilities develop and it is widely believed that age does not determine development alone, **Ormrod (2014)** summarizes Piaget's basic assumptions about children's cognitive development in the following way:

- Children are active and motivated learners.
- Children's knowledge of the world becomes more integrated and organized over time.
- Cognitive development depends on interaction with one's physical and social environment.
- The processes of equilibration (resolving disequilibrium) help to develop increasingly complex levels of thought.
- Children learn through the processes of assimilation and accommodation.
- Cognitive development can occur only after certain genetically controlled neurological changes occur.
- Cognitive development occurs in four qualitatively different stages.

Implications of Child Development Theory for Education

One frequently expressed instructional principle based on Piaget's stages is the need for concrete examples and experiences when teaching abstract concepts to young children who may not yet have reached a formal operations stage. Piaget himself repeatedly expressed a lack of interest in how his work applied to school-based education, calling it "the American question," but today's early childhood and elementary curricula reflect many of Piaget's beliefs about children's developmental levels. Piaget pointed out that much learning occurs without any formal instruction as a result of the child's interacting with the environment. However, constructivist educators tend to claim Piaget as the philosophical mentor who guides their work.

Implications of Child Development Theory for Technology Integration

Piaget's pupil, mathematician Seymour Papert (1928–2016) of the Massachusetts Institute of Technology, used Piaget's theories as the basis of his work with Logo. This environment provided the vital link that Papert felt would allow children to move more easily from the concrete operations or earlier stages of development to more abstract (formal) operations. Papert's 1980 book, Mindstorms, challenged then-current instructional goals and methods for mathematics and became the first constructivist statement of educational practice with technology.

Many technology-using teachers feel that using visual resources such as Logo and simulations can help raise children's developmental levels more quickly than would have occurred through maturation. Thus, children who use these resources can learn higher level concepts that they normally would not have been able to understand until they were older. Other educators feel that young children should experience things in the “real world” before seeing them represented in the more abstract ways they are shown in software, for example, in computer simulations.

Discovery Learning

Educational theorist Jerome Bruner (1915–2016) was interested in children’s stages of cognitive development and believed that children go through three stages of intellectual development (**Schunk, 2012**):

- **Enactive stage** (from birth to about age 3)—Children perceive the environment solely through actions that they initiate. They describe and explain objects strictly in terms of what they can do with them. The child cannot tell how a bicycle works but can show what to do with it. Showing and modeling have more learning value than telling for children at this stage.
- **Iconic stage** (from about age 3 to about age 8)—Children can remember and use information through imagery (mental pictures or icons). Visual memory increases and children can imagine or think about actions without actually experiencing them. Decisions are still made on the basis of perceptions rather than language.
- **Symbolic stage** (from about age 8)—Children begin to use symbols (words or drawn pictures) to represent people, activities, and things. They have the ability to think and talk about things in abstract terms. They can also use and understand what Gagné would call “defined concepts.” For example, they can discuss the concept of toys and identify various kinds of toys rather than defining them only in terms of toys they have seen or handled.

They can better understand mathematical principles and use symbolic idioms such as “Don’t cry over spilt milk.”

Implications of Discovery Learning for Education

Bruner was very concerned that school instruction builds on the stages of cognitive development. Bruner’s theories are associated with unstructured learning activities that he called **discovery learning**. Discovery learning is “an approach to instruction in which students construct their own knowledge about a topic through firsthand interaction with an aspect of their environment” (**Ormrod, 2014**, p. G-4). They do this “by randomly exploring and manipulating objects or perhaps by performing systematic experiments” (**Ormrod, 2014**, p. **405**). Bruner felt that students were more likely to understand and remember concepts they had discovered in the course of their own exploration. However, research findings have yielded mixed results for discovery learning, and the relatively unstructured methods recommended by Bruner have not found widespread support (**Eggen & Kauchak, 2013**; **Ormrod, 2014**). Teachers have found that discovery learning is most successful when students have prerequisite knowledge and undergo some structured experiences.

Implications of Discovery Learning for Technology Integration

Many of the more “radical constructivist” uses of technology employ a discovery learning approach suggested by Bruner. For example, rather than telling students how logic circuits work, a teacher might allow students to use a simulation that lets them discover the rules themselves. Most school uses of technology, however, are what **Eggen and Kauchak (2016)** call a guided discovery learning approach. For example, a teacher may introduce a video-based problem scenario and then help students develop their approaches to solving the problem.

Multiple Intelligences Theory

Of all the learning and developmental theories embraced by constructivists, Howard Gardner's (1943–) is the only one that attempted to define the role of intelligence in learning. Gardner's **multiple intelligences theory** is based on Guilford's pioneering work on the structure of intellect (**Eggen & Kauchak, 2016**) and Sternberg's view of intelligence as influenced by culture (**Ormrod, 2014**). **Gardner's theory (1983)** posits that at least eight different and relatively independent types of intelligence exist, summarized in **Table 2.1**.

Table 2.1 Eight Types of Intelligences

Type of Intelligence	Description	Reflected in Types of Professions or People
Linguistic	• Uses language effectively • Is sensitive to the uses of language • Writes clearly and persuasively	Writer, journalist, poet
Musical	• Understands musical structure and composition • Communicates by writing or playing music	Composer, pianist, conductor
Logical-	• Reasons logically in math terms	Scientist, mathematician,

mathematical	• Recognizes patterns in phenomena • Formulates and tests hypotheses and solves problems in math and science	doctor
Spatial	• Perceives the world in visual terms • Notices and remembers visual details • Can recreate things after seeing them	Artist, sculptor, graphic artist
Bodily kinesthetic	• Uses the body skillfully • Manipulates things well with hands • Uses tools skillfully	Dancer, athlete, watchmaker
Intrapersonal	• Is an introspective thinker • Is aware of one's own motives • Has heightened metacognitive abilities	Self-aware/self-motivated person
Interpersonal	• Notices moods and changes in others • Can identify motives in others' behavior • Relates well with others	Psychologist, therapist, salesperson
Naturalist	• Can discriminate among living things	Botanist, biologist

Implications of Multiple Intelligences Theory for Education

If Gardner's theory is correct, IQ tests (which tend to stress linguistic and logical-mathematical abilities) may not be a comprehensive or accurate way to judge a student's ability to learn, and traditional academic tasks may not be the best reflection of ability. **McDevitt and Ormrod (2010)** also warn that if intelligence is culture dependent or culturally sensitive, children from different cultures will have different forms of intelligent behavior. Teachers, then, should try to determine which type or types of intelligence each student has and direct the student to learning activities that capitalize on these innate abilities. Also, teachers should consider learning activities based on distributed intelligence when each student makes a different but valued contribution to creating a product or solving a problem.

Implications of Multiple Intelligences Theory for Technology Integration

Gardner's theory meshes well with the trend toward using technology to support group work. When educators assign students to groups to develop a multimedia product, they can assign roles to students based on their type of intelligence. For example, a group of students conducting a research project might distribute responsibilities with those with high interpersonal intelligence could be the project coordinators, those with high logical–mathematical ability can be responsible for data analysis and charts, and those with spatial ability can be responsible for presentation aesthetics.

Social Constructivist Theory Foundations for Technology Integration

Methods

Figure 2.3 shows how these six theories contribute to strategies for constructivist technology integration.

Figure 2.3 Theoretical Foundations for Constructivist Technology Integration Strategies

These theories were designed to address a problem that John Seely Brown (1940–) called **inert knowledge**, a term introduced by Whitehead in 1929 to mean skills that students learned but did not know how to transfer later to problems that required their application (**Brown, Collins, & Duguid, 1989**). Brown said that inert knowledge resulted from learning skills in isolation from each other and from real-life application; thus, he advocated cognitive apprenticeships, or activities that called for authentic problem solving, that is, solving problems in settings that are familiar and meaningful to students (**Cognition and Technology Group at Vanderbilt, 1990**). These ideas were based on the theories of Dewey, Bandura, Vygotsky, Piaget, and Bruner.

Today's technology-enabled environments are designed to provide learning environments that reflect **situated cognition**, or instruction anchored in experiences that learners considered authentic because they emulate the behavior of experts in the disciplines. These kinds of materials were intended to assist teachers in helping students build on or "scaffold" from experiences they already had to generate their own knowledge in an active, hands-on way rather than receiving it passively. Today's constructivist integration strategies often focus on having students use data-gathering tools (e.g., mobile technologies) to study problems and issues in their locale, on creating multimedia products to present their new knowledge and insights, on immersing themselves in simulated inquiry-based environments, and on communicating with others around the globe.

Application Exercise 2.1 Key Terms for

Directed from Constructivist Theories

Technology Integration Strategies Based on Directed and Constructivist Theories

Objectivists and constructivists view learning and the kinds of problems (or different aspects of the same problems) confronting teachers and students in today's schools differently. This section compares common approaches with instruction and assessment and technology integration strategies that reflect each theoretical approach.

Instruction and Assessment in Directed and Constructivist Theories

Table 2.2 summarizes and compares how objectivists and constructivists view directed and constructivist instructional needs, methods of instruction, and assessment strategies differently. Instructional problems identified by both objectivists and constructivists are common in most schools and classrooms regardless of grade level, type of student, or content.

Table 2.2 Directed and Constructivist Instructional Needs, Methods, and Assessment

Directed Instructional Models	Constructivist Models

Instructional Needs	
• Accountability: All students must meet required education standards to be considered educated. • Individualization: This helps meet individual needs of students working at many levels. • Quality assurance: The quality of instruction must be consistently high across teachers and schools in various locations. • Convergent thinking: All students must have the same skills.	• Higher-level skills: All students must be able to think critically and creatively and solve problems. • Cooperative group skills: This helps students learn to work with others to solve problems. • Increase relevancy: Students must have active, visual, authentic learning experiences that relate to their own lives. • Divergent thinking: Students must think on their own and solve novel problems as they occur.
Methods of Instruction	
• Stress individualized work. • Have specific skill-based instructional goals and objectives that are the same for all students. • Transmit a set body of skills and/or knowledge to students. • Have students learn prerequisite skills required for each new skill. • Provide sequences of carefully structured presentations and activities to help students understand (process), remember (encode and store), and transfer (retrieve) information and skills. • Use teacher-directed methods and materials: lectures, skill worksheets.	• Stress group-based, cooperative work. • Have global goals such as problem solving and critical thinking that sometimes differ for each student. • Have students generate their own knowledge through experiences anchored in real-life situations. • Have students learn lower-order skills in the context of higher-order problems that require them. • Provide learning through problem-oriented activities (e.g., “what if” situations); visual formats and mental models; rich, complex, learning environments; and exploration. • Use materials to promote student-driven exploration and problem solving.

Assessment Strategies	
• Assessments (e.g., multiple choice, short answer) emphasize knowledge recall with specific expected responses; student products (e.g., essays) are graded with checklists or rubrics.	• Assessments (e.g., group products such as web pages, multimedia projects) emphasize application of knowledge with varying contents or portfolios; student products are graded with self-report instruments, rubrics.

Teachers may use some directed instruction as the most efficient means of teaching required skills while implementing motivating, cooperative learning activities to ensure that students want to learn and that they can transfer what they learn to problems they encounter.

Teachers may design and implement directed and/or constructivist instruction based on (1) their own view of knowledge and learning, (2) the dominant theoretical views within their school, or (3) views built into premade curriculum or other materials. As teachers design technology-supported lessons, they must consider the tenets of directed instruction and constructivist approaches to select technology resources and integration methods that are best suited to their specific needs. In summary,

- **Directed instruction** could be best for providing a foundation of skills. Systematic approaches ensure that specific prerequisite skills are learned.
- **Constructivist learning** may be best for developing the ability to build and apply experience-based knowledge to unique problems.

Figure 2.4 shows examples of four technology integration strategies based primarily on directed models, four based on constructivist models, and four strategies used to address either model. These will be described in more detail in the following sections.

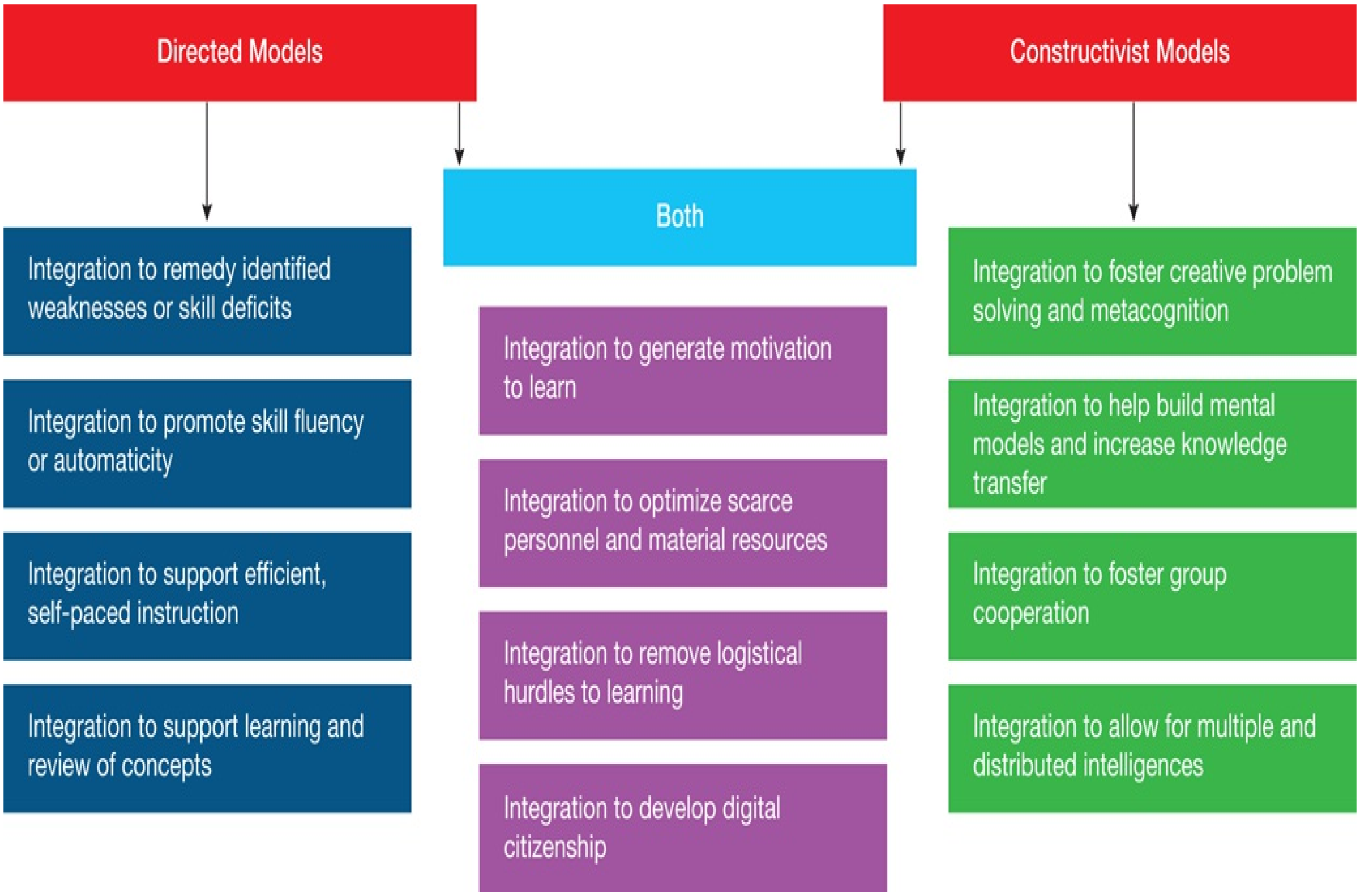


Figure 2.4 Technology Integration Strategies for Directed, Constructivist, or Both Models

Technology Integration Strategies Based on Directed Models

The four integration strategies based on directed methods primarily address individual instruction and practice (see **Table 2.3**).

Table 2.3 Technology Integration Strategies Based on Directed Teaching Models

Integration Strategy	Needs and Problems Addressed	Example Activities
To remedy identified weaknesses or skill deficits	• Students need individual instruction and practice. • Students fail parts of high-stakes tests.	Tutorial or drill and practice software is targeted to identified skills.
To promote skill fluency or automaticity	• Students need to be able to recall and apply lower-level skills quickly and automatically. • Students need to review for upcoming tests.	Drill and practice or instructional game software lets students practice math facts, vocabulary, or spelling words.
To support efficient, self-paced learning	• Students are motivated and able to learn on their own. • No teacher is available for the content area.	Use tutorial software or distance learning courses for subjects.
To support learning and review of concepts	• Students need help studying for tests. • Students need make-up instruction for missed work.	Use tutorial, drill and practice, or podcasts to cover or review specific concepts.

Integration Strategies Based on Directed Models to Remedy Identified Weaknesses or Skill Deficits

Students need to learn prerequisite skills required to advance their knowledge in deeper ways. However, experienced teachers know that even motivated students do not always learn skills as expected. These challenges occur for a variety of reasons, some related to learners' internal capabilities, to teachers' instruction, or to the topic and materials. When the absence of prerequisite skills presents a barrier to higher-level learning or to passing tests, directed instruction may be the most efficient way of providing these skills. In addition to human interventions such as tutoring, materials such as drill and practice and tutorial software have proven to be valuable resources for providing this kind of individualized instruction. Some students who need more instruction to learn required skills may find technology-based materials more motivating and less threatening than teacher-delivered instruction.

Integration Strategies Based on Directed Models to Promote Skill Fluency or Automaticity

Some prerequisite skills must be applied quickly and without conscious effort in order to be most useful. **Gagné (1982)** and **Bloom (1986)** referred to this automatic recall as **automaticity**. Students need rapid recall and performance of a wide range of skills throughout the curriculum, including simple math facts, grammar and usage rules, and spelling. Some students acquire automaticity through repeated use of the skills in practical situations whereas others acquire it more efficiently through isolated practice. Drill and practice, instructional games, and, sometimes, simulation courseware can provide practice tailored to individual skill needs and learning pace.

Integration Strategies Based on Directed Models to Support Efficient, Self-Paced Learning

When students are self-motivated and have the ability to structure their own learning, the most desirable method is often the one that offers the fastest and most efficient path. Sometimes these students are interested in topics not being covered in class or for which there is no instructor available. Directed instruction for these students can frequently be supported by well-designed, self-instructional tutorials and self-paced distance learning workshops and courses.

When students cover a number of topics over time, they usually need a review prior to taking a test to help them remember and consolidate concepts. Sometimes students are absent when in-class instruction was given or need additional time going over the material to understand and remember it. In these situations, drill and practice, tutorial software, and podcast materials are good ways to provide these self-paced reviews.

Integration Strategies Based on Directed Models to Support Learning Concepts

Teachers often teach extensive content concepts through teacher-directed lectures. Some could use digital materials to support such teaching, such as using digital presentations, pictures, videos, and other digital materials that help represent the content to students.

Technology Integration Strategies Based on Constructivist Models

This section reviews the four integration strategies identified with constructivist methods. The strategies are summarized in **Table 2.4**.

Table 2.4 Technology Integration Strategies Based on Constructivist Models

Integration Strategy	Needs and Problems Addressed	Example Activities
To foster creative problem solving and metacognition	• Students need to be able to solve complex, novel problems as they occur. • Teachers want to encourage students' self-awareness of their own learning strategies.	• Video-based scenarios illustrate problems and help support student problem solving. • Concept mapping tools illustrate concepts and support student manipulation of variables. • Reflective thinking through blogging helps build metacognition. • Simulations allow exploration of how complex systems work.
To help build mental models and increase knowledge transfer	• Students have trouble understanding complex	• Video-based scenarios illustrate problems.

	and/or abstract concepts. • Students have trouble seeing where skills apply to real-life problems.	• Serious games and simulations combine skill and knowledge building to solve lifelike challenges. • Virtual field trips and problem-solving software illustrate and let students explore complex environments or systems.
To foster group cooperation skills	• Students need to be able to work with others to solve problems and create products.	Students communicate and collaborate to: • Do effective Internet research. • Learn from diverse sources locally and globally. • Create multimedia expressions of learning. • Design solutions.
To allow for multiple and distributed intelligences	• Students need multiple ways to learn and to demonstrate achievement.	• Use collaborative online tools to facilitate group activities • Support peer-, teacher-, and media-based scaffolding through communicative technologies. • Accept a range of multimedia expressions of learning. • Knowledge expressions are built and distributed across group members.

Integration Strategies Based on Constructivist Models to Foster Creative Problem Solving and Metacognition

Many people believe that our world is too complex and technical for students to learn everything they might need for the future. Thus, our knowledge society is beginning to place a high value on the ability to solve novel problems in creative ways. If students are conscious of the procedures they and others use to solve problems, they often can more easily improve on their strategies and become more effective, creative problem solvers. Consequently, teachers often try to present novel problems (sometimes with unknown solutions) to students to solve and to get them to analyze how they learn to solve them. Resources such as problem-solving simulations and multimedia applications are often considered ideal environments for getting students to think about how they think and for offering opportunities to challenge their creativity and problem-solving abilities.

Integration Strategies Based on Constructivist Models to Help Build Mental Models and Increase Knowledge Transfer

The problem of inert knowledge is believed to arise when students learn skills in isolation. When they later encounter problems that require the skills, students do not realize how the skills could be relevant. Problem-solving materials in highly visual, interactive, and sometimes immersive formats allow students to build rich mental models of problems to be solved. For example, **serious games**, which teach skills and build knowledge in these highly visual, problem-solving environments, help ensure that students build higher order skills, retain understandings over time, and transfer knowledge to other problem contexts. These technology-based methods are especially desirable for teachers who work with students in areas such as mathematics and science whose concepts are abstract and complex and whose inert knowledge is a frequent focus.

Integration Strategies Based on Constructivist Models to Foster Group Cooperation Skills

Students need the ability to work cooperatively in a group to communicate and collaborate, construct knowledge, solve problems, and design solutions (**Lynch, Lynch, & Bolyard, 2013**; **Schul, 2011**; **Wirth, 2013**). Although schools certainly can teach cooperative work without technology resources, a growing body of evidence documents students' appreciation of cooperative work as both more motivating and easier to accomplish when it uses technology (**Chin, 2013**; **Vargas, 2013**). In **Figure 2.5**, three boys work cooperatively toward a shared learning goal.

Figure 2.5 Three boys learning together with tablets

Integration Strategies Based on Constructivist Models to Allow for Multiple and Distributed Intelligences

Integration strategies with group cooperative activities also give teachers a way to allow students of widely varying abilities to make valuable contributions on their own terms. Because each student is an important member of the group in these activities, the activities themselves are viewed as problems for group—

rather than individual—solution. This strategy foregrounds students' assets; engages peer-, teacher-, and media-based scaffolding as a way for students to accomplish tasks; and produces knowledge distributed across the group.

Technology Integration Strategies Useful for Either Model

We highlight four technology integration strategies that support instructional needs in both directed and constructivist models as summarized in **Table 2.5**.

Table 2.5 Technology Integration Strategies to Support Either Model

Integration Strategies	Needs and Problems Addressed	Example Activities
To generate motivation to learn	• Students need motivation to learn. • Students need to see the relevance of new concepts and skills to their lives. • Students need to be active rather than passive learners.	• Visual and interactive qualities of the Internet and multimedia resources draw and hold students' attention. • Drill and practice/tutorial materials give students private environments for learning and practice. • Video-based scenarios and simulations show relevance of science and math skills. • Hands-on production work (e.g., multimedia, web pages) gives students an active role in learning.

To optimize scarce personnel and material resources	• Schools have limited budgets; therefore, they must save money on consumables or content materials. • Teachers are in short supply in some subject areas. • Students cannot travel to places to learn about them.	• Simulations allow repeated science experiments at no additional cost. • Distance courses can offer subjects for which schools lack teachers. • Rich content materials available on the web (e.g., NASA images) can extend textbook-based materials • Virtual tours allow students to see places which they could not go physically.
To reduce logistical hurdles	• Students find repetitive tasks (handwriting, calculations) boring and tedious. • Some design prototypes are too costly or time consuming to produce. • Some social and physical phenomena occur too slowly, too quickly, or at too great a distance to allow observation.	• Word processing makes quick, easy revisions and corrections to written work. • Calculators and spreadsheets do low-level calculations involved in math/science problem solving. • 3-D printers can be used to develop prototypes. • Simulations allow study of social systems (e.g., voting) and physical systems (chemical reactions).
To develop digital citizenship	• Students must understand and manage their digital identity. • Students must honor intellectual property of digital materials. • Students need to learn methods for communicating respectfully and safely online. • Digital content has varying quality and accuracy.	• Research reports as multimedia products or web pages must use copyright-free or Creative Commons digital content. • Students should track their digital identities, ensuring that no personal identifying information is available. • Methods for evaluating the accuracy, credibility, and relevance of online information should be implemented.

Integration Strategies Useful for Either Model to generate motivation to learn

Teachers say that capturing students' interest and enthusiasm is key to success; frequently, they cite it as their greatest challenge. Some educators assert that today's entertainment-immersed students are increasingly likely to demand more motivational qualities in their instruction than students in previous generations did. Constructivists argue that instruction must address students' affective needs as well as their cognitive ones, saying that students will learn more if what they are learning is interesting and relevant to their needs. They recommend the highly visual and interactive qualities of Internet and multimedia resources as the basis of these strategies. Proponents of directed methods make similar claims about highly structured, self-instructional learning environments. These individuals say that some students find learning at their own pace in a private environment very motivating because they receive immediate feedback on their progress. It seems evident that appropriate integration strategies to address motivation problems depend on the needs of the student; either constructivist or directed integration strategies can be used to increase motivation to learn.

Integration Strategies Useful for Either Model to Optimize Scarce Resources

Current resources and numbers of personnel in schools are rarely optimal. Computer-based courseware and web-based materials can help make up for the lack of required resources—from consumable supplies to qualified teachers

—in the school or classroom. For example, drill and practice programs can replace worksheets, a good distance program can offer instruction in topics for which local teachers are in short supply, an online fieldtrip can allow global visits, and a simulation program can let students repeat experiments without depleting chemical supplies or other materials.

Integration Strategies Useful for Either Model to Reduce Logistical Hurdles

Some technology tools offer no instructional sequence but help students complete learning tasks more efficiently than other tools. For example, word processing programs do not teach students how to write, but they let students write and rewrite more quickly without the labor of handwriting. Computer-aided design (CAD) software does not teach students how to design a house, but it allows them to try out designs and features to see what they look like before building models or structures. A calculator lets students do lower-level calculations so they can focus on the high-level concepts of math problems. A website might contain only a set of pictures of sea life, but it lets a teacher illustrate concepts about sea creatures more quickly and easily than he or she could with books.

Integration Strategies Useful for Either Model to Develop Digital Citizenship

Many teachers recognize the need for students to develop responsible, legal, and ethical digital practices in order to live and work in our digital, global world. As teachers adopt directed and constructivist technology integration strategies, they can inherently provide opportunities for students to practice and demonstrate digital citizenship. For example, when students develop digital, multimedia presentations, they must consider copyright and attributions for materials they incorporate. When using technology to communicate and collaborate with others near or far, students must develop positive and safe interactions online. As they use and create digital materials, students need to become aware of and manage their growing digital identity that is tied to everything they do online.

Turn-around Technology Integration Pedagogy and Planning (TTIPP) Model

This section introduces a model to help teachers plan to integrate technology into their teaching. Now that you know a range of technology integration strategies and the learning theories that gave rise to them, let's turn to how to choose the optimal strategies in practice. Any well-designed lesson takes planning. The Turn-around Technology Integration Pedagogy and Planning (TTIPP) model in **Figure 2.6** is an everyday process model that is useful when teachers decide that they would like to try to use digital technologies for teaching or if they face requirements to use technology. This process enables selecting the best pedagogical strategies and technological resources to teach their curriculum.

Phase 1: Analysis of Learning and Teaching Assets and Needs

Step 1: Analyze problems of practice (POPs)

Step 2: Assess technological resources of students, families, teachers, and the school

Step 3: Identify technological possibilities

Phase 2: Design of the Integration Framework

Step 4: Decide on learning objectives and assessments

Step 5: Design integration strategies and determine relative advantage

Step 6: Prepare the instructional environment and implement the lesson

Phase 3: Post-Instruction Analysis and Revisions

Step 7: Analyze lesson results and impact

Step 8: Make revisions based on results

Step 9: Share lessons, revisions, and outcomes with other peer teachers

Figure 2.6 The Turn-around Technology Integration Pedagogy Planning Model

Each step in the model's three phases helps ensure that technology use will be meaningful and successful in meeting learning needs through the process of building a revitalized curriculum that engages all students. Aspects of this TTIPP model are inspired by turn-around pedagogies, a term coined by **Kamler and Comber (2005)** to describe a process in which teachers engaged to revitalize their curriculum that re-engaged students (in particular, at-risk students) in content area learning, and has been applied to developing digital literacies by **Alvermann, Hutchins, and McDevitt (2012)**. Turning around is a long-term, everyday process that involves teachers in (1) exploring their students' lived experiences and identifying how these experiences are assets for learning, (2) inquiring into research-based perspectives on equity and learning, and (3) examining students' learning challenges in relation to current pedagogy and curriculum that might not privilege all students' capabilities, knowledge, and interests. Teachers who innovate to engage learners and their parents characterize highly effective schools (**Fullan, 2016**; **James, Connolly, Dunning, & Elliot, 2006**; **McLaughlin & Talbert, 2001**). Kamler and Comber's research was situated within teacher research networks and thus emphasized continual sharing and learning with peer teacher colleagues. We have integrated aspects of turn-around pedagogies into our TTIPP model.

Teachers experienced in using technology might perform these TTIPP steps intuitively. However, for new teachers or those just beginning to integrate technology, the TTIPP model provides a helpful guide on procedures and issues to address. The following sections discuss each of its component steps and give examples of tasks and products required in each step. As you read about the TTIPP model, we illustrate the phases through a classroom example of a teacher, Ms. Mian, building an online multicultural project.

Phase 1: Analysis of Learning and Teaching Assets and Needs

In this phase of technology integration, teachers analyze teaching and learning problems, identify current technological assets, and determine the possible technologies that might address the problems. This section describes Phase 1 analysis steps and explains why each is necessary.

Step 1: Analyze Problems of Practice (POPs)

Every teacher has topics—and sometimes whole subject areas—that have proven challenging to teach. Some concepts are so abstract or foreign to students that they struggle to understand them; some students find some topics so boring, tedious, or irrelevant that they have trouble attending to them. Some learning requires time-consuming tasks that students resist doing. Good teachers try to meet these challenges by making concepts more engaging or easier to grasp, making tasks more efficient to accomplish, or completely rethinking curriculum goals. The first step in planning for technology integration is to identify problems in your practice that need changing.

- **What is the meaningful problem of practice?** To make sure a technology application is a good solution, begin with a clear statement of the teaching and learning problem. This is sometimes difficult to do but is essential to ensure that technology adoptions solve problems. Use the following guidelines when answering the question “What is a meaningful problem of practice?”
  - Focus on discipline-specific knowledge, skills, or dispositions that reveal difficulty in students’ learning or the teacher’s instruction of important disciplinary concepts. These problems would significantly impair students from successful progression in the discipline.
  - Assess the nature and frequency of the disciplinary learning activities for real-world relevancy and deep learning, often achieved through inquiry, critical thinking, complex problems, collaboration, and creative solutions.
  - Examine the students’ roles in learning, determining whether students have some level of agency, autonomy, and engagement in learning activities.
  - Look for observable indications of the problem, such as student test scores revealing consistently lower achievement in a knowledge area; formal or informal observations showing teachers have trouble explaining concepts; or the school’s adopting a new curriculum.

Step 2: Assess Technological Resources of Students, Families, Teachers, and the School

A successful technology-enhanced lesson requires leveraging student technological strengths, teacher technology knowledge and skills, and school-based technological resources (i.e., hardware, software, other media, and support) to turn around the problems identified in Step 1. First, teachers must understand the technological experiences of their students, their families, and the communities in which the school is located. Second, teachers need to take stock in their own technological knowledge, such as considering their depth of knowledge of technological pedagogical content knowledge (TPCK) (review **Figure 1.4**). Third, teachers must assess the technological resources available in their school and classroom. You will garner more success if you plan technology integration with supporting conditions in mind. That means asking the following questions:

- **Question 1: Who are my students as digital technology users and what are they capable of doing with technology?** To help you design technology-supported lessons, knowing the nature of digital practices that your students engage in is worthwhile. You can come to understand their digital capabilities and access to technology equipment, software, and the Internet in and out of school. Your students could have a range of technological activity sites, including their homes, their parent's workplaces, community libraries or centers, and homes of other family members or friends in addition to what occurs in school. The digital knowledge they possess are assets that you can capitalize on in lesson planning, and the digital knowledge they lack can also inform you about digital literacy practices that will need to be taught in advance of or during a lesson. We suggest the following sources for assessing this information:
    - **Surveys or questionnaires**—Check with your school to determine whether it collects any information on digital practices of students or parents through surveys or questionnaires, such as participation in ED School Climate Surveys (EDSCLS), Project Tomorrow's annual Speak Up survey, non-profit YouthTruth's STEM survey, or other state or local surveys. As a teacher, you could create a questionnaire specific to your interests using free survey software and access to a range of survey questions, such as those in Speak Up or Pew Research Center's Internet and Tech surveys.
    - **Home/community visits**—If time was available, teachers have found home visits or community walks to be immensely valuable in

understanding more about the students they teach. Cremin, Mottram, Collins, Powell, and Drury (2012) called these "learner visits" (p. 104) and found that they challenged teachers' preconceived perceptions of the students and their families. Likewise, the students in your classroom could hail from a range of communities, so taking walks and observing life in these areas proves informative. Be sure to visit the libraries and community centers.

    - **Student Share**—Teachers can also invite students to select digital artifacts they have created outside of school and teach the class about its creation. Alternatively, teachers could set up a collaborative online sharing space, such as a cloud-based storage area or folder in a learning management software to which students could upload and annotate their digital artifacts.

- **Question 2: What are my technical knowledge, skills, and attitudes?** Teachers must self-assess their own technological knowledge, skills, and attitudes in order to identify strengths and weaknesses as they begin to plan for technology integration. This assessment in the case of identified strengths is a source for technological ideas for lessons. In the case of identified weaknesses, the assessment can lead to areas for further professional learning or opportunities for collaboration with other teachers, librarians, and media specialists who might have more expertise. As an example, Shelby-Caffey, Úbéda, and Jenkins (2014) highlight the process that a teacher, Bethany, undertook to turn around her technophobic beliefs and practices and embrace digital storytelling as a way to transform her teaching and the students' learning. As part of a grant that provided classroom technologies, she received training and ongoing support that pushed her out of her technophobic comfort zone.
- **Question 3: What technology resources exist in my school?** Remember that this textbook defines technology resources as technology tools (e.g., media, software, and hardware) and technology support and expertise. As you join a school, assess the resources available. You can

obtain this information from school leaders, librarians, media specialists, and your peer teachers. Consider the following:

- **Computers and Internet**—Are there enough computers available to support individual computing, pairs, small groups, or whole class? Is there a computer laboratory? Are there mobile carts of computers or tablets? What is the availability of access to these computing resources, and how can you reserve them? How robust is the Internet in your classroom?
- **Software and media**—What software, media packages, or apps are available? Remember that making copies of published software or media is illegal, even if copies are used on a temporary basis.
- **Peripherals**—What is the access to printers, paper, and other special peripherals such as scanners, digital cameras, video cameras and headphones?
- **Technology support**—Who do you ask for help when you have technical difficulties, such as crashing computers, printer errors, or projector malfunctions? How is best to contact these individuals—through the phone, email, or a help center?
- **Technology integration expertise**—Who has expertise with technology integration that might be available for idea brainstorming, lesson plan development, or co-teaching? What is the availability of these experts and how can you schedule time with them?

Step 3: Identify Technological Possibilities

In Step 3, you need to identify technological possibilities for solving the problem of practice. Technology-based strategies offer many benefits to teachers as they look for instructional solutions to this problem. Being able to recognize specific instances of these problems in a classroom context and knowing how to match them with an appropriate technology solution require knowledge of classroom problems, practice in addressing them, and an in-depth knowledge of the characteristics of each technology. With the problem of practice that you have identified in your own classroom, use your knowledge of learning theories, technology resources at your school from Step 2, and integration strategies described in **Tables 2.2** through **2.4** to identify possible technology solutions to your problem of practice. Inherent in these possibilities, you will determine whether your new methods should be primarily directed or constructivist:

- Use directed strategies when students need an efficient way to learn specific skills that must be assessed with traditional tests.
- Use constructivist strategies when students need to develop global skills and insights over time (e.g., cooperative group skills, approaches to solving novel problems, mental models of highly complex topics) and when learning may be assessed with alternative measures, such as portfolios or group products.

Read how Ms. Mian, the teacher, moves through the steps in Phase 1 of TTIPP in **Technology Integration Example 2.1**.

Phase 2: Design of the Integration Framework

This phase requires teachers to make decisions about learning objectives and how they will be assessed, how to arrange and carry out integration strategies, and how technology integration provides a relative advantage over past approaches.

Step 4: Decide on Learning Objectives and Assessments

Writing learning objectives is a good way to set clear expectations for what technology-based methods will accomplish (i.e., outcomes) and to allow later measurement of how much these expectations have been met (i.e., assessment). For example, teachers may expect that a new method will improve student behaviors, which will result in better achievement, more on-task behavior, or improved attitudes. Sometimes changes in teacher behaviors are important—for example, saving time on a task or helping to re-engineer curriculum. In either case, objectives should focus on outcomes that are observable (e.g., demonstrating, writing, completing, re-engineering) rather than on internal results that cannot be seen or measured (e.g., being aware, knowing, understanding, or appreciating).

After stating learning objectives, teachers create ways to assess how well outcomes have been accomplished. Sometimes, they can use existing assessment instruments. In other cases, they have to create instruments or methods to measure the behaviors. Here are a few example outcomes, objectives (which are used to state outcomes in a measurable form), and assessment methods matched to the outcomes:

- **Higher achievement outcome**—Overall average performance on an end-of-chapter test will improve by 20%. (Assess achievement with a test.)
- **Cooperative work outcome**—All students will score at least 15 of 20 on the cooperative group skill rubric. (Use an existing rubric to assess skills.)
- **Attitude outcome**—Students will indicate satisfaction with the simulation lesson by an overall average score of 20 of 25 points. (Create an attitude survey to assess satisfaction.)

- **Improved motivation**—Teachers will observe better on-task behavior in at least 75% of the students. (Create and use an observation sheet.)

Technology Integration

Example 2.1

TTIPP Phase 1 Analysis of Learning and Teaching Assets and Needs

Ms. Mian wanted to include more meaningful multicultural activities in the social studies curriculum because she and the other social studies teachers in her school focused primarily on studying various holidays and foods from other cultures. The teachers sponsored an annual international foods smorgasbord that was very popular with the students, but she doubted that it taught them much about the richness of other cultures or why they should respect and appreciate cultures different from their own. She sometimes overheard her students making disparaging comments about people in other ethnic groups and felt a better approach to multicultural education might help.

Ms. Mian remembered a workshop she had attended the previous summer in which teachers in another school district described an online project with partner schools in countries around the world. One teacher told about her partners in Israel, Spain, Mexico, and Kenya and said that students exchanged information with designated partners and answered assigned questions to research each other's backgrounds and locales. Then the students worked in groups to make travel brochures or booklets to email to each other. They even took digital photos and videos of themselves to send. It sounded like a great way for kids to learn about other cultures in a meaningful way while learning some geography and civics. The teachers in the workshop had remarked that it was difficult to demean people who look and talk differently than you do when you've worked with and gotten to know them. Ms. Mian was so impressed with the online project they had described that she decided to try it out in her own classroom. She knew her school had robust Internet and tablet access with a range of media software. Most of her students had used email and multimedia software outside of school. Even though she had not seen it modeled, she felt she could structure a good curriculum around these activities once she knew about what was needed.

Phase 1 Analysis Questions

1. What is the problem of practice Ms. Mian wants to address?
2. What evidence does she have that there is a problem?
3. What technological assets do students possess that could be used in a lesson?
4. What technology resources exist at the school that might support technological solutions to the problem?
5. What technological possibility does Ms. Mian identify to solve this problem of practice?
6. What special skills or resources does Ms. Mian need to implement such a project?

Table 2.6 offers a range of resource suggestions for meeting assessment activities.

Table 2.6 Assessment Resources for Teachers

Assessment Activity	Resources
Online surveys (most have a free, limited-feature option as well as a fee-based option)	• Qualtrics • Google Forms • SurveyMonkey • Zoomerang • SurveyMethods • Kahoot!
Rubric makers and free prepared rubrics	• Kathy Schrock's Guide to Everything • RubiStar • iRubric app
Testmakers and quiz makers	• ContentGenerator.net • QuizStar • Qzzr • Engageform

This step in Phase 2 requires answering two questions about outcomes and assessment strategies:

- **Question 1: What outcomes do I expect from using the new methods?** Think about problems you are trying to solve and what would be acceptable indications that the technology solution has succeeded in resolving them. Use the following guidelines:
  - **Focus on results, not processes**—Think about the end results you want to achieve rather than the processes to help you get there. Avoid

statements that focus on a process that students use to achieve an outcome, such as “Students will learn cooperative group skills.” Instead, state what you want students to be able to do as a result of having participated in the multimedia project—for example, “90% of students will score 4 of 5 on a cooperative group skills rubric.”
    - **Make statements observable and measurable**—Avoid vague statements that cannot be measured; for example, “Students will understand how to work cooperatively.”
- **Question 2: What are the best ways to assess these outcomes?** The choice of assessment method depends on the nature of the outcome. Note the following guidelines:
    - **Use tests to assess skill achievement outcomes**—Cognitive tests (e.g., short answer, multiple choice, true/false, matching) and essay exams remain the most common classroom assessment strategy for many formal knowledge skills.
    - **Use evaluation criteria checklists to assess complex tasks or products**—When students must create complex products, such as multimedia presentations, reports, or web pages, teachers can give students a **multimedia checklist like the one shown**, which is a set of criteria that specify the requirements each product must meet, to guide their project. The teacher uses the criteria to award points for meeting each criterion.
    - **Use rubrics to assess complex tasks or products**—**Rubrics like the one shown** fulfill the same role as evaluation criteria checklists and are sometimes used in addition to them. A **rubric** is an instrument consisting of a set of elements that define important aspects of a given performance or product and provide ratings that describe levels of quality for each element. Rubrics’ added value is giving students descriptions of various levels of quality. Teachers usually associate a letter grade with each level of quality (Level 5 = A, Level 4 = B, etc.).
    - **Use Likert scale–type surveys or semantic differentials to assess**

attitude outcomes—When the desired outcome is to improve attitudes, teachers design a survey in Likert scale format or with a **semantic differential**. A **Likert scale** is a series of statements that students use to indicate their degree of agreement or disagreement. A **semantic differential** requires students to respond to a question by checking a line between each of several sets of bipolar adjectives to indicate their level of feeling about the topic of the question. The teacher sums the item scores on these surveys or semantic differentials to obtain a measure of student perceptions.

Teachers use **observation instruments** to measure frequency of behaviors. For example, if teachers wanted to see an increase in students' use of scientific language, they could create a chart to keep track of this use on a daily basis so they could track baseline performance and improvement over time.

Some technologies, such as drill and practice software or adaptive learning software, have built-in formative and summative assessments of students' knowledge.

Step 5: Design Integration Strategies and Determine Relative Advantage

What usually drives integration design decisions is whether the learning environment will be primarily directed (a teacher or expert source presents information for students to absorb) or primarily constructivist (students do activities to generate their own learning). In light of this decision, which you made in Step 3, consider each of the following implementation decisions to narrow down your integration strategy:

- **Question 1: What kind of content approach do I need to use?** Should the approach be a single subject or interdisciplinary? Sometimes school or district requirements dictate this decision, and sometimes teachers combine subjects into a single unit of instruction as a way to cover concepts and topics they may not otherwise have time to teach. Most often, however, interdisciplinary approaches are used to model how real-life activities require the use of a combination of skills from several content areas.
- **Question 2: What grouping approach should I use?** Should the students work as individuals, in pairs, in small groups, or as a whole class? This decision is made in light of how many computers or software copies are available as well as the following purposes:
  - **Whole class**—For demonstrations or to guide whole-class discussion prior to student work.
  - **Individual**—When students have to demonstrate individual mastery of skills at the end of the lesson or project.
  - **Pairs**—For peer tutoring when higher ability students work with those of lower ability or for collaboration in dyads.
  - **Small group**—To model real-world work skills by giving students experience in cooperative group work.
- **Question 3: How can I prepare students adequately to use technologies?** When designing a sequence of activities that incorporates technology tools, be sure to consider your students' technological assets and needs. Allow enough time for demonstrating the tools to students and allowing them to become comfortable using them before they do a graded product.

Once you have an integration strategy, you are ready to consider the benefits of new technology methods compared to the past ones and decide whether there will be significant benefits. **Everett Rogers (2003)**, an expert on why and how people adopt innovations, called this seeing a **relative advantage**. **Hughes (2000**; **2005**) developed the Replacement, Amplification, and

Transformation (RAT) assessment model to help teachers assess, or RATify, the relative advantage of technology-supported lessons. During the assessment, a teacher should examine the following three aspects of the lesson in which the technology use will be embedded: (1) instructional method, (2) student learning processes, and (3) curriculum/content goals. Hughes developed three use categories from educational theory, classroom observations, and interviews with teachers. They include:

- **Replacement**—Technology used as replacement replicates and does not change established instructional practices, student learning processes, or content goals. The technology serves merely as a different, technological means to the same instructional end. Think of technology as a proxy, stand-in, or surrogate.
- **Amplification**—Technology used as amplification increases efficiency or intensifies productivity in current instructional practices, student learning, or content goals (**Cole & Griffin, 1980**; **Pea, 1985**). The focus is effectiveness or streamlining rather than change. **Cuban (1988)** described this as a first-order change for which technology is used to "try to make what exists more efficient and effective without disturbing the basic organizational features . . . " (p. **93**). **Fishman and Dede (2016)** refer to this as "doing conventional things better" (p. 1269). Think of technology as enlargement (larger, greater, stronger), addition of detail (fuller, clearer), or increase in magnitude.
- **Transformation**—Technology used for transformation shifts, restructures, or reorganizes instructional methods, the students' learning processes, and/or the actual subject matter in ways unavailable without the inclusion of the technology **(Pea, 1985)**. Transformation is akin to **Cuban's (1988)** notion of second-order changes that produce "new goals, structures, and roles that transform familiar ways of doing things into novel solutions to persistent problems" (p. **94**). **Fishman and Dede (2016)** frame this as "doing better things" (p. 1269) by completely rethinking how learning and

instruction may occur with technologies. Think of technology as change, conversion, revolution, renovation, restructure, and reorganization.

To RATify a technology's contribution to a lesson, a teacher can use the **RAT matrix** to guide consideration of how an instance of technology use impacts instructional methods, student learning processes, and curriculum goals, each of which can be further articulated by identifying more specific dimensions within each.

Hughes developed the RAT model and matrix for use by teachers who are planning or have taught technology-supported lessons. Individual digital technologies (e.g., PowerPoint, an ELMO, GIS software) cannot be assessed using the RAT model without the rich instructional information about the context of a digital technology's use in teaching and learning. The model supports teacher assessment of lessons because the rich instructional information is typically known only by the teacher or someone who co-planned, co-observed, or co-teaches with the teacher.

We exemplify using the RAT matrix to assess the role of technology in a lesson richly described by **Conn (2013)**. In this lesson, a first grade teacher integrated the use of live web-cam video of animals living in captivity and wild habitats for a unit on habitats. For 5 weeks, students used iPads to observe animals daily, note characteristics, and research habitats. The lesson culminated with an illustrated report (see **Figure 2.7**).

Figure 2.7 RATifying the Conn (2013) Lesson with the Replacement, Amplification, Transformation (RAT) Matrix

	Instruction	Learning	Curriculum
Replacement			

Technology is different means to same end.		• Read magazines online • Drew habitat in a drawing app • Wrote report about habitat in writing app	• Met 1st grade science standards-observing and comparing habitats
Amplification Technology increases or intensifies efficiency, productivity, access, and capabilities, etc., but the tasks stay fundamentally the same.	• More efficient everyday access to video streams with iPads vs. computer lab • Increased variety of live habitats	• Customized habitat sorting activity in app	
Transformation Technology redefines, restructures, reorganizes, changes, or creates novel solutions.	• Changed length of time habitats could be observed (5 weeks)	• Created a real-world, authentic observational experience for learners	• Lesson became interdisciplinary with science, research, reading, writing, and technology

The RAT categories do not provide a linear path to technology integration such as starting with R activities, then moving to A, and ultimately to T. Research shows that teachers will have an array of R, A, and T technology integration practices in their teaching but transformative practices are sometimes elusive (**Blanchard, LePrevost, Tolin, & Gutierrez, 2016**; **Gao, Chee, Wang, Wong,**

& Choy, 2011; Hughes, 2005; Kimmons, Miller, Amador, Desjardins & Hall, 2015; Russell & Hughes, 2014). Transformative technology integration emerges from planning processes that privilege subject matter content as when subject-area teachers explore subject problems of practice and explore digital technology as possible solutions (Hughes & Ooms, 2004).

Table 2.7 lists several kinds of learning problems and technology possibilities with potential for high relative advantage.

Table 2.7 Technology Possibilities with Potential for High Relative Advantage

Problems of Practice	Technology Possibilities	Relative Advantage
Concepts are new, foreign (e.g., mathematics, physics principles)	Graphic tools, simulations, video-based problem scenarios	Visual examples clarify concepts and applications.
Concepts are abstract, complex (e.g., physics principles, biology systems)	Math tools (Geometer's SketchPad, simulations, problem-solving software, spreadsheet exercises, graphing calculators)	Graphics displays make abstract concepts more concrete; students can manipulate systems to see how they work.
Time-consuming manual skills (e.g., handwriting, calculations, data collection) interfere with learning high-level skills	Tool software (e.g., word processing, spreadsheets and probeware)	Takes low-level labor out of high-level tasks; students can focus on learning high-level concepts and skills.

Students find practice boring (e.g., basic math skills, spelling, vocabulary, test preparation)	Drill and practice software, instructional games	Attention-getting displays, immediate feedback, and interaction combine to create motivating practice.
Students cannot see relevance of concepts to their lives (e.g., history, social studies)	Simulations, Internet activities, video-based problem scenarios	Visual, interactive activities help teachers demonstrate relevance.
Skills are "inert" (i.e., can do them—e.g., mathematics, physics—but do not see where they apply)	Simulations, problem-solving software, video-based problem scenarios, student development of web pages, multimedia products	Project-based learning using these tools establishes clear links between skills and real-world problems.
Students dislike preparing research reports, presentations	Student development of desktop-published and web page/multimedia products	Students like products that look polished, professional.
Students need skills in working collaboratively, opportunities to demonstrate learning in alternative ways	Student development of desktop-published and web page/multimedia products	This provides a format in which group work makes sense; students can work together "virtually"; they make different contributions to one product based on their strengths.
Students need technological competence in preparation for the	All software and productivity tools; all communications, presentation, and multimedia software	Illustrates and provides practice in skills and tools students will need in work situations.

workplace		
Teachers have limited time for correcting students' individual practice items	Drill and practice software, handheld computers with assessment software	Feedback to students is immediate; frees teachers for work with students.
No teachers available for advanced courses	Self-instructional multimedia, distance courses	Provides structured, self-paced learning environments.
Students need individual reviews of missed work	Tutorial or multimedia software	Provides structured, self-paced environments for individual review of missed concepts.
Schools have insufficient consumable materials (e.g., science labs, workbooks)	Simulations, e-books	Materials are reusable; saves money on purchasing new copies.
Students need quick access to information and people not locally available	Internet and email projects; multimedia encyclopedias and atlases	Information is faster to access; people are easier, less expensive to contact.

The degree to which these solutions might replace, amplify, or transform your practice depends on your specific teaching context. RATifying your technology-supported lessons enables you to understand the technology's advantage relative to past practices. If you are not satisfied with the ways in which your technology-supported lesson will provide a relative advantage, you can go back to Step 3 to reconsider other technological possibilities and continue through the TTIPP steps in sequence.

Step 6. Prepare the Instructional Environment and Implement the Lesson

This step requires answering two questions about preparing an instructional environment that will support technology integration:

- **Question 1: How should resources be arranged to support instruction and learning?** Guidelines here include:
  - **Access for students' needs**—For students with visual, hearing, physical, or cognitive differences, consider software or adaptive devices created especially to address these needs. An important concern here is universal design for learning (UDL). For more on this, see the Adapting for Special Needs feature in **Box 2.1**.

BOX

2.1: Adapting for Special Needs: Universal Design for Learning

Universal design for learning (UDL) is a framework that has important implications for technology use in the classroom. UDL proactively addresses academic diversity through strategies that offer students multiple ways to access, engage, and demonstrate their mastery of the learning outcomes. One of the mantras of UDL is that instructional design deliberately created for individuals with disabilities often provides significant benefits to all students. The essence of UDL involves providing three components:

- Multiple means of representation to give learners various ways of acquiring information and knowledge
- Multiple means of engagement to tap into learners' interests, to challenge them appropriately, and to motivate them to learn
- Multiple means of expression to provide learners with alternatives for demonstrating what they know

Traditionally, when educators fail to recognize that 25–50% of the students in their classroom might not read at grade level, they distribute textbooks that have a readability level above grade level. However, using the principle of multiple means of representation, an educator plans instruction to provide access to digital text so that students can manipulate the physical nature of the text (e.g., change the font size, color contrasts), as well as alter the cognitive difficulty by using tools such as text-to-speech (e.g., Natural Reader website) or text-summarization (e.g., Text Compactor website). Learn more about universal design for learning in order to understand its applications for your own classroom by visiting the Center for Applied Special Technology or CAST website.

—Contributed by Dave Edyburn

- **Privacy and safety issues**—Ensure you uphold technology use policies. You may need to remind students of guidelines for acceptable technology use, especially when you use the Internet. These policies hold students accountable for equipment and their actions while using technology.
- **Classroom management**—You need to anticipate and develop strategies to manage students' behavior when technology is in use. Your

knowledge of how much time is required to teach particular technologies and how many of your students will need the technology instruction will reveal students who may need other different assigned tasks. Further, the more you can envision or anticipate potential student problems with the technologies, the more focused supporting materials you can provide.

- **Supporting materials**—Prepare, copy (or post), or model necessary support materials. You can consider creating summary sheets to remind students how to do basic operations, create or link to "how-to" videos (e.g., lynda.com or Atomic Learning), or be prepared to model and explain technology procedures.

- **Question 2: What steps are required to make sure technology resources work well?** Guidelines here include:
  - **Troubleshooting**—Computers, like all machines, occasionally break down. Learn simple diagnostic procedures so you can correct some problems without assistance. Know whom to contact and how to receive technical support in your classroom.
  - **Test runs**—Spend time learning and practicing using resources before students use them, but also retry the resources just before class begins.
  - **Backup alternatives**—Have a backup plan in case something goes wrong at the last minute.

With knowledge of your learning objectives, prepared assessments, chosen integration strategies, and prepared instructional environment, you are ready to implement your technology-supported lesson! Read how Ms. Mian, the teacher, engaged in designing her integration framework for her multicultural unit in **Technology Integration Example 2.2**.

Phase 3: Post-Instruction Analysis and

Revisions

This section gives a detailed description of Phase 3 steps and an explanation of why each is necessary. As teachers complete a technology-supported project with students, teachers begin reviewing evidence of how successful the strategies and plans were in solving the identified problems. Teachers use this evidence to decide what should be changed with respect to objectives, strategies, and implementation tasks to ensure even more success next time. Their results can be shared with colleagues.

Step 7. Analyze Lesson Results and Impact

To do a post-instruction analysis, teachers look at the following issues:

- **Were the objectives achieved?** This is the primary criterion of success of the activity. Teachers review achievement, attitude, and observation data they have collected and decide whether the technology-based method solved the problem(s) they had identified. These data help them determine what should be changed to make the activity work better.
- **What do students say?** Some of the best suggestions on needed improvements come from students. Informal discussions with them yield a unique student perspective on the activity.

Technology Integration

Example 2.2

TTIPP Phase 2 Design of the Integration

Framework

Ms. Mian reflected on the problems she saw with her current multicultural goals and what she wanted her students to learn about other cultures that they didn't seem to be learning. She decided on the following three learning outcomes: better attitudes toward people of other cultures, increased learning about similarities and differences among cultures, and knowledge of facts and concepts about the geography and government of the other country they would study. So that she could measure the success of her project later, she created objectives and instruments to measure the outcomes:

- **Attitudes toward cultures**—At least 75% of students will demonstrate an improved attitude toward the culture being studied with a higher score on the post-unit attitude measure than on pre-unit measure. Instrument: She knew a good way to measure attitudes was with a semantic differential. Before and after the project, students would answer the question: "How do you feel about people from ______?" by marking a line between sets of adjectives to indicate how they feel.
- **Knowledge of cultures**—Each student group will score at least 90% on a rubric evaluating the brochure or booklet that reflects knowledge of the cultural characteristics (both unique and common to our own) about the people being studied. Instrument: After listing characteristics she wanted to see reflected in the products, she found a product rubric to assess them. She decided they should get at least 15 of the 20 possible points on this rubric.
- **Factual knowledge**—Each student will score at least 80% on a short-answer test on the government and geography of the country being studied.

Next, Ms. Mian designed the integration strategies. She knew that her students would not achieve the insights and changed attitudes she had in mind using the strategy of telling them information and testing them on it. They would need to draw their own conclusions by working and communicating with people from other cultures. However, she felt she could use a directed approach to teach them the Internet and email skills they would need to carry out project activities. The project website suggested setting up groups of four with designated tasks for each group member. It also suggested the following sequence of activities for introducing and carrying out the project:

Step 1: Teacher signs up on the project website; obtains partner school assignments.

Step 2: Teachers in partner schools make contact and set a timeline.

Step 3: Teachers organize classroom resources for work on project.

Step 4: Teacher introduces the project to students: Displays project information from the website and discusses previous products that appear on other sites.

Step 5: Teacher assigns students to groups; discusses task assignments with all members.

Step 6: Teacher determines students' email and Internet skills; begins teaching those skills needed.

Step 7: Students make initial email contacts/chats and introduce themselves to each other.

Step 8: Teacher works with groups to identify information for final product.

Step 9: Students search the Internet to locate required information;

take digital photos and scan required images; exchange information with partner sites.

Step 10: Students do production work; exchange final products with partners.

Step 11: Teacher debriefs and assesses student work.

Next, Ms. Mian took time to identify the relative advantage of the proposed online project by using the RAT model. When she thought deeply about the role(s) technology played in the lesson, she RATified it in the following way:

	Instruction	Learning	Curriculum
Replacement Technology is a different means to same end.			▪ Teach facts about geography and government
Amplification Technology increases or intensifies efficiency, productivity, access, and capabilities etc., but the tasks stay fundamentally the same.		▪ Use Internet to research facts about countries	▪ Teach about digital citizenship: email communication and Internet research
Transformation Technology redefines, restructures, reorganizes, changes, and creates novel solutions.	▪ Collaborate with teachers in other countries to co-teach a lesson	▪ Use video, pictures, email communication to build and share cultural knowledge ▪ Use team-based work ▪ Produce digital	▪ Move beyond culture simply by addressing food and holidays ▪ Experience and exchange cultural knowledge with cultural

		products	insiders in other countries

Based on her RATification of the lesson, Ms. Mian felt this online project was worthwhile, so she began to prepare her instructional environment. First, she examined the timeline of project activities so she would know when her students needed to use computers. She made sure to build in enough time to demonstrate the project site and to prepare her students to use the browser and search engine responsibly. Then she began the following planning and preparation activities:

- **Supports for students**—To make sure that groups knew the tasks each member should do, Ms. Mian created handouts specifying timelines and what should be accomplished at each stage of the project. She also made a checklist of information that students were to collect and made copies so that students could check off what they had done as they went along. She wanted to make sure everyone would know how she would grade their work, so she made copies of the assessments (the rubric and a description of the country information test) that she would hand out and discuss with the students.
- **Computer schedule**—Ms. Mian had five Internet-connected computers, so she set up a schedule for small groups to use the computers. She knew that some students would need to scan pictures, download image files from the digital camera, and process those files for sending to the partner schools, so she scheduled some additional time in the computer lab for this work.

She thought that students could do other work in the library/media center after school if they needed still more time.

Phase 2 Analysis Questions

1. What are Ms. Mian’s learning objectives for the lesson?
2. What kinds of assessments is Ms. Mian using to assess the outcomes of her lesson?
3. Is Ms. Mian’s lesson strategy primarily directed or constructivist?
4. What grouping strategy did Ms. Mian choose? Why?
5. Do you see any other relative advantages of the online project she is proposing: Are there other ways this lesson replaces, amplifies, or transforms practice?
6. Ms. Mian was concerned about students revealing too much personal information about themselves to people in their partner schools. What guidelines should she give them about information exchanges to protect their privacy and security?

- **Could improving instructional strategies improve results?** Technologies in themselves do not usually improve results significantly; it is the way teachers use them that is critical. Look at the design of both the technology use and the learning activities surrounding it.
- **Could improving the environment improve results?** Sometimes a small change, such as better scheduling or access to a printer, can make a big difference in a project’s success.
- **What is the contribution of the technology to instruction, student learning, or curriculum content? How well has the technology integration strategy worked?** Refer to how you RATified your lesson during Step 5. Did the technology replace, amplify, or transform instruction,

learning, and curriculum as you expected? You can also use the **Assessment Tools: Technology Impact Checklist** to determine how the activity has added relative advantage as compared to what you have done before.

Check the available data you have:

- **Achievement data**—If the problem was low student achievement, do data show that students are achieving better than they were before? If the goal was improved motivation or attitudes, are students achieving at least as well as they did before? Is higher achievement consistent across the class, or did some students seem to benefit more than others?
- **Attitude data**—If the original problem was students' low motivation or refusal to do required work, are there indications that this behavior has improved? Has it improved for everyone or just for certain students?
- **Students' comments**—Be sure to ask both lower-achieving, average-achieving, and higher-achieving students for their opinions. Even if achievement and motivation seem to have improved, what do students say about the activity? Do they want to do similar activities again?

- **What could be improved to make the technology integration strategy work better?** The first time you engage in a technology-based activity, you can expect that it will take longer and you will encounter more challenges than you will in subsequent uses. The following areas are most often cited as needing improvement:
  - **Scheduling**—If students request any change, it is usually for more time. This may or may not be feasible, but you can review the schedule to determine whether additional time can be built in for learning software and/or for production work.
  - **Technical skills**—It usually takes longer than expected for students to learn the technology tools. How can this learning be expedited or supported better?

- **Efficiency**—From the teacher's point of view, the activity took longer than expected to plan and carry out. If the impact on outcomes is significant, the extra time may be worth it.

Step 8. Make Revisions Based on Results

Based on the results from Step 7, teachers make adjustments to materials, logistics, and/or strategies. Revision activities are on a continuum ranging from making small changes in how materials are used to going back to Step 1 and re-analyzing the problem–solution match. Evidence in the form of student outcomes must drive these decisions.

As a planning tool, the TTIPP model makes concrete the questions that teachers need to think through when designing instruction that uses technology. The combination of theory foundation and thoughtful planning make technology integration purposeful, effective, and meaningful for teachers and students alike.

Step 9. Share Lessons, Revisions, and Outcomes with Other Peer Teachers

All of your hard work planning and implementing a technology-supported lesson could have a significant impact on the students in your classroom. You can extend that impact by sharing your original or revised lesson with colleagues near and far. Collaboration with colleagues to share innovations in teaching and learning can powerfully motivate and engage teachers in the teaching profession (**Fullan, 2016**). **McLaughlin and Talbert (2001)** identified the fact that teachers were more persistent in innovating when they shared resources and practices collaboratively with colleagues.

Your school or district may have digital spaces for sharing lessons with other teachers; you could share with content-area organization sharing areas (e.g., listserv or websites); you can post it online and share a link to others on social networking sites such as Twitter; or you could even monetize your work by selling it on Teachers Pay Teachers as long as your district allows this. Read how the teacher, Ms. Mian, analyzed the results of her lesson and shared outcomes with her peers in **Technology Integration Example 2.3**.

Technology Integration

Example 2.3

TTIPP Phase 3 Post-Instruction Analysis and Revisions

Ms. Mian was generally pleased with the results of the multicultural project. According to the semantic differential, most students showed a major improvement in how they perceived people from the country they were studying. Students she had spoken with were very enthusiastic about their chats and email exchanges. Some group brochures and booklets were more polished than others, but they all showed good insights into the similarities and differences between cultures, and every group had met the rubric criteria on content. The web searches they had done seemed to have helped.

One thing that became clear was that production work on their published products was very time consuming; in the future, Ms. Mian would have to either assign a simpler product or change the schedule to allow more time. She also realized that she had to stress that the deadlines were firm. Students would have searched for and taken digital photos forever if she had let them. The searching activity put them behind on making their products and left little time to discuss their findings on comparisons of cultures. Results varied on the short-answer test on the government and geography of the country being studied. Only about half of the students met the 80% criterion. Ms. Mian realized she would have to schedule a review of this information before she gave the test. She decided to make this a final group task after the production work was finished.

Ms. Mian revised her planning documents with these results in mind so that she could implement this project again next year. She met with her grade-level team to share the results and discuss the lesson. They seemed intrigued by the project and in the shift in students' knowledge and attitudes. She also shared a revised version of her lesson with her media specialist who added it to a district online collaboration area for teachers that has a space to upload technology-supported lessons.

Phase 3 Analysis Questions

1. If Ms. Mian found that only five of the seven groups in the class were doing well on their final products, what might she do to find out more about why this was happening?
2. Although all of Ms. Mian's groups did well on content overall, rubric scores revealed that most groups scored lower in one area: spelling, grammar, and punctuation in the products. What steps could Ms. Mian take to revise the production work checklist that might improve this outcome next time?
3. What benefits might Ms. Mian experience by sharing her lesson with others

Chapter 2 Summary

1. **Overview of successful technology integration planning and practice**—Two learning theories have given rise to two types of integration models: directed and constructivist. A turn-around technology integration pedagogy and planning model requires knowledge of learning theories to enable transformative technology integration planning.
2. **Directed integration models were shaped by objectivist theories**—Leading theories included behaviorist (Skinner), information-processing (Atkinson and Shiffrin), cognitive-behavioral (Gagné), and systems theories. Directed technology integration strategies are typically systematically designed, structured learning products such as drills, tutorials, and adaptive or personalized learning systems.
3. **Constructivist integration strategies were based on constructivist learning theories**—Prominent theories include social activism (Dewey), social learning (Bandura), scaffolding (Vygotsky), child development (Piaget), discovery learning (Bruner), and multiple intelligences (Gardner) theories. Constructivist integration strategies call for solving problems in settings that are familiar and meaningful to students; they often focus on having students use data-gathering tools to study problems and issues in their locale, on creating multimedia products to present their new knowledge and insights, on immersing oneself in simulated inquiry-based environments, and on communicating with others around the globe.
4. **Contrasting technology integration strategies based on theories**—Directed integration strategies aim to remedy identified weaknesses or skill deficits; to promote skill fluency or automaticity; to support efficient, self-paced learning; and to support self-paced review of concepts.

Constructivist integration strategies aim to foster creative problem solving and metacognition; to help build mental models and increase knowledge transfer; to integrate and foster group cooperation skills; and to integrate allowing for multiple and distributed intelligences. Integration strategies common to both directed and constructivist models include generating motivation to learn, optimizing scarce resources, removing logistical hurdles to learning, and developing digital citizenship.

5. **The Turn-around Technology Integration Pedagogy and Planning (TTIPP) Model**—This model is designed to help teachers plan for successful and transformative classroom uses of technology. The model consists of nine steps within three phases:
   Phase 1: Analysis of Learning and Teaching Assets and Needs

   Phase 2: Design of the Integration Framework

   Phase 3: Post-Instruction Analysis and Revisions

Technology Integration Workshop

1. Apply What You Learned

You have read in this chapter how technology integration activities vary according to directed and constructivist views of learning and pedagogy and can replace, amplify, or transform aspects of instruction, learning, or curriculum. Now apply your understanding of these concepts by doing the following activities:

Reread Mr. Ng and Ms. Rodriguez's lessons in Technology Integration in Action: The Role of Learning Theory at the beginning of the chapter. Reflect on each lesson's approach to teaching and learning and determine which one reflects a directed or a constructivist approach. Identify how the respective theories underlie the practices in the lessons (see **Figures 2.2** and **2.3** for assistance).

Review how Ms. Mian RATified her lesson in the **Technology Integration Example 2.2**. Now, try using the **RAT Matrix** to analyze the role technology played in Mr. Ng and Ms. Rodriguez's lessons described in Technology Integration in Action: The Role of Learning Theory at the beginning of the chapter. Reflect on the role technology plays as replacement, amplification, and/or transformation of instruction, student learning, and/or curriculum. Do you feel that the ways technology was integrated provided relative advantage?

2. Technology Integration Lesson Planning: Evaluating Lesson Plans

Complete the following exercise using sample lesson plans found on the web or provided by your instructor.

a. Locate technology-supported lessons—Identify three lesson plans that focus on any of the strategies you learned about in this chapter. For example, select those that reflect:
   - Directed integration strategies
   - Constructivist integration strategies
   - Integration strategies useful to support either directed or constructivist approaches

b. Evaluate the lessons—Use the Technology Lesson Plan Evaluation Checklist and the RAT Matrix to evaluate each of the lessons you found. Based on the evaluation and your RATification of the lessons, would you adopt these lessons in the future? Why or why not?

3. Technology Integration Lesson Planning: Creating Lesson Plans with the TTIPP Model

Review how to implement the TTIPP Model (see **Figure 2.6**) for technology integration planning. Create your own technology-supported lesson by doing the following:

a. Describe Phase 1—Analysis of Learning and Teaching Assets and Needs:
    - What is the problem of practice or main content topic in your lesson?
    - What are the technology resources that your students, their families, you, and your school could bring as assets for the lesson?
    - What are the technological possibilities for helping to solve the identified problem of practice? Identify the technology(ies) you will integrate into the lesson and ensure that you have skills and resources you need to carry it out.

b. Describe Phase 2—Design of the Integration Framework:
    - What are the objectives of the lesson plan?
    - How will you assess your students' accomplishment of the objectives?
    - What integration strategies are used in this lesson plan?
    - What is the relative advantage of using the technology(ies) in this lesson?
    - How would you prepare the learning environment?

c. Describe Phase 3—Post-instruction Analysis and Revisions:
    - What strategies and/or instruments would you use to evaluate the success of this lesson in your classroom in order to determine revision needs?
    - Add lesson descriptors—Create descriptors for your new lesson (e.g., grade level, content and topic areas, technologies used, ISTE standards, 21st-Century Learning standards).
    - Save and share your new lesson—Save your lesson plan with all its descriptors and TTIPP Model notes and share it with your peers, teacher, and others.

When you use your new lesson with students, be sure to assess it using the Technology Impact Checklist.