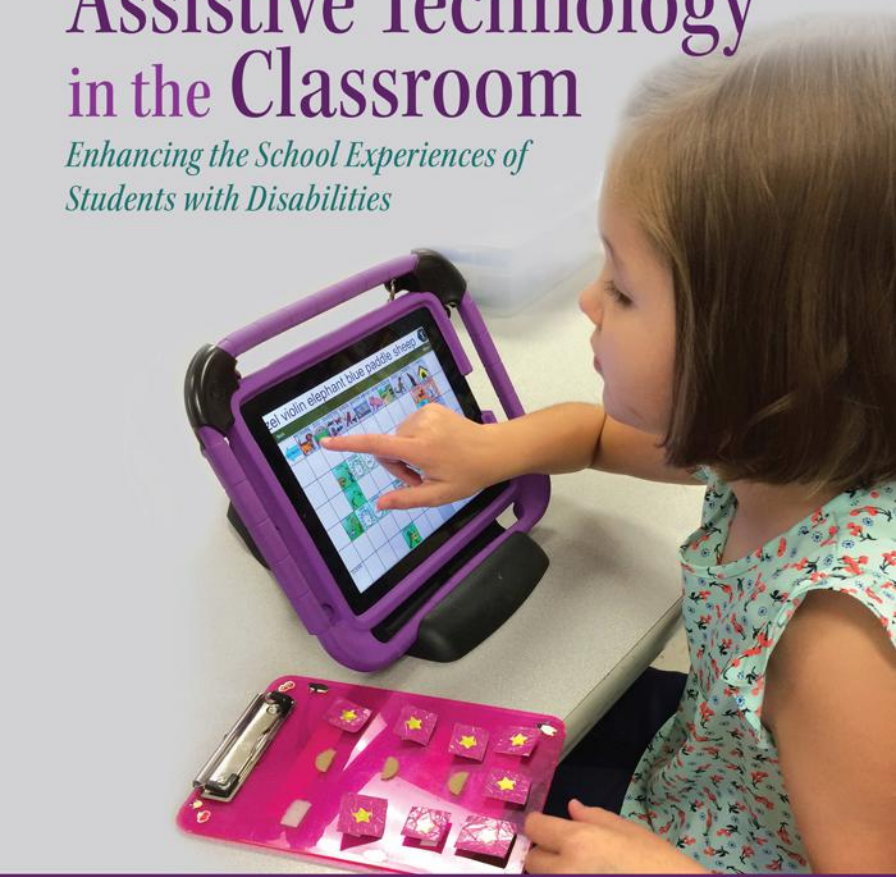
Third Edition

Assistive Technology in the Classroom

Enhancing the School Experiences of Students with Disabilities



Amy G. Dell • Deborah A. Newton • Jerry G. Petroff

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PEARSON

In memory of my mother, Jessie Glasser,
and in honor of my father, Arnold Glasser

Amy G. Dell

To my husband, John, who makes my dreams come true,
and to our son, Sean, for the love and humor he brings to our lives

Deborah A. Newton

To my husband, David, and our sons, Parker and Borey,
for their unconditional love and support

Jerry G. Petroff

ABOUT THE AUTHORS

Amy G. Dell is a professor and graduate coordinator in the Department of Special Education, Language and Literacy at The College of New Jersey. She has been involved in assistive technology training since the advent of Apple IIe computers and adaptive firmware cards, through the days of floppy disks, Muppet Keys, and Unicorn Boards, to today's embrace of mobile devices and "the cloud." She teaches graduate courses in assistive technology and is dedicated to preparing current and future teachers to use assistive technology to enhance the learning of their students who have disabilities. Through the Center for Assistive Technology and Inclusive Education Studies (CATIES), which she directs, she strives to connect people who have disabilities with technology tools that will increase their independence and participation in school, work, home, and community activities.

Deborah A. Newton is currently a professor and Interim Associate Dean of the School of Education at Southern Connecticut State University in New Haven, Connecticut. Previously she served as chairperson of the Department of Special Education and Reading and coordinator of the master's concentration in assistive technology, a program in which she taught several courses. Before moving to higher education, she spent 15 years as a classroom teacher, and then served as the assistive technology specialist at the Center for Enabling Technology in Whippany, New Jersey. She holds a doctorate in curriculum and instruction from the University of Cincinnati, a master's degree from The College of New Jersey, and a bachelor's degree from the State University of New York at New Paltz. Dr. Newton presents regularly at assistive technology conferences and remains active as an assistive technology consultant.

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PREFACE

Assistive Technology in the Classroom: Enhancing the School Experiences of Students with Disabilities, Third Edition, continues the second edition's emphasis on the integration of assistive technology into the curriculum—how assistive technology can be used in schools to enhance the teaching and learning of students with disabilities. It addresses the challenge of how *teachers* can use assistive technology in all kinds of classrooms both to teach new skills to students with all kinds of disabilities and to provide *students* with access to the general education curriculum. The context for this text's discussions of technology use is always the classroom, the school, and other environments in which students learn. This approach reflects the philosophy of the leading professional organization in educational technology, the International Society for Technology in Education (ISTE), which emphasizes that technology is not an end in itself, but rather a means to participation and learning (Knezek, Bell, & Bull, 2006).

NEW TO THIS EDITION

The rapid pace of change in the computer industry has the unfortunate side effect of rendering many technology tools obsolete within three years, and sometimes even sooner. The upside to this rapid pace of innovation is that exciting new products and trends become available in the same three-year period. These two trends created a strong need to update the technical information and resources provided in the second edition of this text. Keeping readers abreast of relevant new developments in assistive technology that hold tremendous promise for students with disabilities is the primary intent of the revision of this text.

The major changes to the third edition are as follows:

- Each chapter has been updated to include discussions of iPads and other mobile devices, examples of appropriate apps, and descriptions of best practices in the use of mobile technology in special education. Where possible, screenshots of specific apps have been added to appropriate chapters. A process for evaluating the appropriateness of apps for use with students who have disabilities is presented in Chapter 5.
- Information on *all* technology tools—apps, websites, assistive devices, and operating systems—has been updated to reflect the most current products, including the latest operating systems from Microsoft, Apple, and Google. All Internet addresses (URLs) in the Web Resources sections and References sections have been updated as well. Readers now have access to the most current information and resources related to the integration of assistive technology into teaching and learning.
- A new Chapter 7 has been added: Assistive Technology to Create Visual Supports and Promote Positive Behavior. This addition reflects the current interest in technology tools that can improve the educational experiences of students with autism. In this chapter, readers learn how to create picture schedules, activity sequences, and social stories using symbol systems such as Boardmaker and easy-to-use apps. Students with autism can then access the visual supports on mobile devices or computers.
- Links to YouTube videos have been added to every chapter via margin notes. Two kinds of videos have been highlighted. First, some videos provide step-by-step instructions on how to use specific apps that are mentioned in the chapter. Second, some videos show real people who have disabilities using the technology being discussed and explaining the impact the technology has on their lives. Seeing real people using the assistive technology they are reading about provides a helpful context for readers and helps them understand the importance of assistive technology.
- In addition to all chapters being updated, the chapter on decision making and selecting assistive technology tools has been significantly expanded. Knowing about specific tools is not enough—teachers need to learn how to match technology tools to a student's specific needs and strengths. This seems to be one of the hardest concepts for teachers new to assistive technology to grasp.

The text's focus on teachers and their role in assistive technology implementation stems from the authors' recognition that one of the major problems contributing to the gap between the *possibilities* of assistive technology and the *successful implementation* of it in our schools is that teachers lack the necessary knowledge and skills. Even in school districts in which assistive technology teams conduct assistive technology evaluations on students with disabilities and make recommendations for appropriate technology tools, many students do not benefit from the recommendations because the professionals with whom they interact on a daily basis—that is, their teachers—are not aware of what assistive technology can do, do not know how to use that technology within the context of their classrooms, and do not know how to support their students' use of it.

The technology solutions included in this text are appropriate for students with a wide range of disabilities. Technology tools that benefit students with low-incidence disabilities such as autism and multiple disabilities are presented, as well as technology solutions for students with high-incidence disabilities such as learning disabilities and attention-deficit disorders. Although some states have teacher certification requirements that are categorical in nature, other states have generic special education certifications. In the latter case, teacher candidates need to be prepared to implement assistive technology with *all* students.

A WORD ABOUT TERMINOLOGY

ASSISTIVE TECHNOLOGY. Other terms are sometimes used to refer to technology that helps students with disabilities. *Rehabilitation technology*, *special education technology*, *educational technology*, *instructional technology*, and *information technology* often overlap and may mean different things to different people (Golden, 1998). As Golden points out, this "definitional ambiguity has fostered an atmosphere of confusion in the development and implementation of assistive technology policies in many settings, especially education" (p. 6). This text uses *assistive technology* to refer to any kind of technology (on mobile devices, laptops, or desktop computers) that help students with disabilities succeed in school.

By maintaining a focus on what teachers need to know about assistive technology, this text avoids becoming a survey of the entire field of assistive technology. Consequently, discussions of assistive technology for positioning and mobility, sports and recreation, architecture, and transportation are not included. Although these technologies are important in addressing quality-of-life issues, they do not directly relate to the instructional process and students' success in schools and, therefore, are not covered in this text. Furthermore, selection of and training to use technology devices in these fields typically fall within the domain of rehabilitation professionals such as physical therapists; that is, they do not rely on the involvement of classroom teachers for their successful implementation.

The activities in which teachers *do* become involved are teaching and learning: teaching reading and writing, listening and speaking, math, functional skills, and content areas. Because this book's focus is on teaching and learning in the classroom, our use of the term *assistive technology* refers primarily to technology that meets the *learning and communication needs* of children and youth with disabilities in school.

EDUCATIONAL AND INSTRUCTIONAL TECHNOLOGY. The terms *educational technology* and *instructional technology* have come to be used interchangeably, but as Roblyer (2003, p. 5) points out, "no single acceptable definition of these terms dominates the field." To ease this confusion, Roblyer has developed the following definitions:

> Educational technology is a combination of the processes and tools involved in addressing educational needs and problems, with an emphasis on applying the most current tools: computers and their related technologies. (p. 6)
>
> "Integrating educational technology" refers to the process of determining which *electronic tools* and which methods for implementing them are appropriate for given classroom situations and problems. (p. 8)

A close reading of these definitions reveals that *assistive technology* could be considered a subset of Roblyer's definition of *educational technology*. Insert the phrase "students with disabilities" and this becomes a good working definition of assistive technology:

> [Assistive] technology is a combination of the processes and tools involved in addressing educational needs and problems [of students with disabilities], with an emphasis on applying the most current tools: computers and their related technologies. (p. 6)

Insert the phrase "integrating assistive technology" into the second definition and it accurately describes that process as well:

> "Integrating [assistive] technology" refers to the process of determining which *electronic tools* and which methods for implementing them are appropriate for given classroom situations and problems. (p. 8)

Although the Technology and Media Division of the Council for Exceptional Children uses the term *special education technology*, we have chosen to use the more neutral *assistive technology* because it does not imply that the technology is limited to students who are educated in special education settings.

ORGANIZATION OF THE BOOK

The link between technology and teaching and learning drives this text's organization as well as its content. Part 1 is organized by *school-related tasks* that students must perform on a daily basis to be successful—writing, reading, accessing the general education curriculum, practicing academic skills, demonstrating what they have learned, communicating with teachers and peers, and understanding what their teachers and peers express. Each chapter in Part 1 begins with a description of the problems students with disabilities face with the specific school-related task, and then goes on to describe how assistive technology can help overcome the problems related to this activity. This structure helps teacher candidates understand how assistive technology fits into their classrooms and curricula. It shifts the focus from training on specific devices and the latest gizmos to training on *how to use the technology to learn.*

After Part 1 has established the benefits of assistive technology for students with disabilities, Part 2 addresses a key question: How can we make computers and mobile devices *accessible* to students who cannot type on a keyboard, use a mouse or touchscreen, hear an alert sound, or see a monitor? Chapters in this section discuss ways to adjust operating systems and specialized access solutions.

Part 3 focuses on augmentative communication—the use of computer technology to provide a voice for students who cannot speak. Chapters 10 and 11 provide essential background information on augmentative communication, while Chapter 12 highlights the teacher's role in integrating augmentative communication in the classroom. The background information in Chapters 10 and 11 is provided because most teachers and teacher candidates have had little, if any, previous training in augmentative communication. Chapter 12 presents strategies that teachers can use in their classrooms to encourage students to develop and refine their augmentative communication skills. This chapter describes how to integrate communication objectives into classroom activities and daily routines and how to provide multiple opportunities for students to use their augmentative communication systems during the school day.

Part 4 is aptly titled "Putting It All Together and Making It Happen." The previous three parts of the text established the value of assistive technology and presented a variety of assistive technology solutions. In this last part, the book moves from possibilities to the nitty-gritty: How do we make these exciting possibilities happen for students with disabilities? What do we need to know, and what do we need to *do* to actually get assistive technology to the students who stand to benefit from it? The answers to these questions are complex and involve a wide range of issues, including the decision-making process for determining appropriate technology tools for a student (Chapter 13); the laws related to assistive technology, the integration of assistive technology into individual education programs (IEPs), the "digital divide," implementation plans, administrative issues, and funding sources (Chapter 14). Chapter 14 also summarizes the typical obstacles to assistive technology implementation in the P–12 realm and presents recommendations for getting around these barriers. Chapter 15 addresses implementation issues specifically related to transitioning from high school, with an emphasis on the need to teach students to self-advocate for their assistive technology needs.

Although disability categories are mentioned within the context of technology-based solutions, this text is *not* organized around disability categories. There is a common misconception in special education that Disability X = Technology Tool Y. In fact, this belief is overly simplistic and misguided. Multiple factors are involved in selecting appropriate technology tools for students with disabilities, and it is a mistake to base selection decisions simply on a child's diagnosis. Therefore, this text discusses disability categories within the context of school-related tasks and technology-based solutions.

PEDAGOGICAL ELEMENTS

The book was designed following the principles of "considerate text": Each chapter begins with a list of learner outcomes, is divided into sections that are labeled with headings and subheadings, and concludes with a summary of key points. Sidebars and tables highlight specialized information. An important pedagogical element new to this third edition is the addition of margin notes that provide links to short videos showing real people with disabilities benefiting from specific assistive technology tools. We recommend that as you proceed through the text, you consciously try to make connections between the information presented and the students whom you teach. Applying the lessons of the text to students with disabilities whom you know will help you understand the subtleties of the assistive technology decision-making process.

Because of the ever-changing nature of technology, the text purposefully presents only a sampling of assistive technology hardware, apps, and websites. A deliberate effort was made to minimize the use of specific product names; indeed, such names have been used only for purposes of illustration. For additional information on specific products and to view photographs or screenshots of them, go to the websites listed in the margin notes and at the end of each chapter in the Web Resources section. This section contains the URLs of websites maintained by manufacturers and publishers of hardware, apps, and assistive devices, as well as links to informative resources. Every effort has been made to provide accurate URLs for all websites. However, if you are unable to access a particular site, we recommend that you go to the site's home page and try to navigate to the specific page using the links included there.

A list of suggested activities is included at the end of each chapter. These in-class or out-of-class activities are designed to involve students more deeply in the chapter's subject matter. All of the suggested activities have proved successful over the past 20 years in assistive technology courses with students who are studying to be special education teachers or technology coordinators. Instructors are encouraged to assign one or more of these activities for each chapter or to assign similar activities of their own design. Many of the activities are hands-on in nature and require a computer or mobile device and specific apps. Others involve interviewing people in the field. All of the activities are designed to *engage students in active exploration* of assistive technology tools or environments in which assistive technology is or could be used to help students make the connection between assistive technology and the learning process.

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We have continued to be inspired by many assistive technology users—students with disabilities, their parents, and adults who have disabilities—who show us by their persistence and accomplishments the power of assistive technology. Thank you to Anthony Arnold, Anthony Bonelli, Dylan Brown, Serena Cucco, Jon Gabry, Michael Lawson, Cory Samaha, Sherlock Washington, Michael Williams, and the many individuals in the YouTube videos mentioned in the text's margin notes who demonstrate the impact of technology tools on their lives.

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BRIEF CONTENTS

CONTENTS

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PART 1

BENEFITS OF TECHNOLOGY USE IN SPECIAL EDUCATION

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1 INTRODUCTION TO ASSISTIVE TECHNOLOGY

Learning Outcomes

1. Explain both parts of the definition of *assistive technology* that is included in IDEA 2004.
2. Describe the assistive technology continuum and give examples of items at each point on the continuum.
3. Describe the laws that underlie the provision of assistive technology to students with disabilities.
4. Discuss assistive technology in the context of the Common Core State Standards.
5. Identify the latest developments in technology that are changing the landscape of assistive technology.
6. Explain why mobile devices are becoming widespread in education.
7. Describe the principles that underlie the philosophy of this text.
8. Identify the components of the SETT Framework for Decision-Making.
9. Describe the concepts of universal design and universal design for learning.

INTRODUCTION

In 1972, when the first author was a sophomore in college, she met an unusual middle-aged man who made a deep impression on her. Bernie had severe cerebral palsy, a neuromuscular condition that significantly affected his movement and posture. He could not walk and had no control over his arms or hands; in fact, he had one of his arms tied across his chest to prevent it from jerking involuntarily and hitting someone. His head control was poor. Most people looking at him sitting in his wheelchair with his head hanging down assumed he could do nothing; they assumed he was as cognitively limited as he was physically limited, and they made no attempt to discover the person inside.

Bernie, however, did not accept other people's low expectations of him. He was determined to find a way around his physical limitations so that he could be an active participant in the world around him. Bernie knew that he had a little control over one of his legs, and he wondered if he might be able to do something with that little voluntary movement. A handy friend attached a metal dowel to the bottom of one of his shoes and placed a rubber tip on the end. With this simple contraption, Bernie was able to type on a typewriter. The only assistance he needed was someone to put the shoe with the dowel on his foot and place the typewriter on the floor next to his foot. His typing speed was slow, but he was now able to write letters to his friends (this was before e-mail), type letters to legislators, and write articles expressing his points of view. Although the term did not exist at this time, this kind of creative problem solving was an early example of *assistive technology*.

The author never forgot Bernie. Today, 43 years later, she still remembers the lessons he embodied: (1) Regardless of how disabled a person may appear, inside is a person who wants to be part of life. (2) Taking a problem-solving attitude, instead of a too-bad-there's-nothing-that-can-be-done attitude, can lead to creative solutions that eliminate or bypass obstacles such as disabilities. (3) Simple technology can change a person's life. These three lessons are what led the author to personal computers when they became available many years later. She had seen with her own eyes that "having a disability no longer has to mean that things cannot be done; it means that we can find new ways to get them done" (Alliance for Technology Access [ATA], 2004, p. 3). And she wanted to be one of those problem solvers—"people who ask not *whether*

Watch how assistive technology has changed one family's experiences on *AssistiveWare—Tell Us, We Want to Know*.

https://youtu.be/-xuUWxIY7SM

something can be done, but rather *how* it can be accomplished" (ATA, 2004, p. 3, italics added). Marc Gold (1980), an early leader in the field of severe disabilities, expressed this philosophy succinctly: "Try another way."

WHAT IS ASSISTIVE TECHNOLOGY?

The term *assistive technology* is defined in the Individuals with Disabilities Education Improvement Act of 2004 (IDEA 2004), the federal law that provides the foundation for all special education services. This law's definition of assistive technology is considered the official definition, and it is important to note that it consists of two parts: assistive technology *devices* and assistive technology *services*. The two are integrally connected and will be explained in this section.

IDEA 2004 defines an assistive technology *device* as "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability" (IDEA 2004, Sec. 1401(1)(A)). (See Figure 1.1 for the complete definition.) Let's examine this definition in reverse. An assistive technology device must have an impact on the *functioning* of a child with a disability. For example, a portable magnifier enables a child who has a visual impairment to read a worksheet, thereby improving his or her ability to complete schoolwork. An iPad app that reads a book aloud helps a child who has learning disabilities comprehend text that is above his or her reading level. A talking augmentative communication system that enables a child who has autism to express preferences increases the child's ability to communicate. These three examples show how an assistive technology device can "increase, maintain, or improve functional capabilities of a child with a disability."

If we look at the first part of the definition—an assistive technology device can be bought in a store ("acquired commercially off the shelf"), it can be a purchased item that has been modified, or it can be something that has been customized for an individual's particular needs. A large computer monitor, an iPad, and a Chromebook are examples of assistive technology devices that can be bought in a store. Another example of off-the-shelf assistive technology is a talking calculator, which provides auditory feedback to a student with learning disabilities who has a problem typing numerals correctly.

FIGURE 1.1 IDEA 2004 definition of assistive technology.

Individuals with Disabilities Education Act (IDEA) of 2004, 20 U.S.C. § 1401

1) ASSISTIVE TECHNOLOGY DEVICE—
   (A) IN GENERAL—The term "assistive technology device" means any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional s of a child with a disability
   (B) EXCEPTION—The term does not include a medical device that is surgically implanted, or the replacement of such device.

2) ASSISTIVE TECHNOLOGY SERVICE—
The term "assistive technology service" means any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device. Such term includes—
   (A) the evaluation of the needs of such child, including a functional evaluation of the child in the child's customary environment;
   (B) purchasing, leasing, or otherwise providing for the acquisition of assistive technology devices by such child;
   (C) selecting, designing, fitting, customizing, adapting, applying, maintaining, repairing, or replacing assistive technology devices;
   (D) coordinating and using other therapies, interventions, or services with assistive technology devices, such as those associated with existing education and rehabilitation plans and programs;
   (E) training or technical assistance for such child, or, where appropriate, the family of such child; and
   (F) training or technical assistance for professionals (including individuals providing education and rehabilitation services), employers, or other individuals who provide services to, employ, or are otherwise substantially involved in the major life functions of such child.

Source: http://uscode.house.gov/ (Pub. L. 106–402, title I, §102, October 30, 2000, 114 Stat. 1682), United States House of Representatives.

FIGURE 1.2 Assistive technology continuum.

Low-Tech Tools	Mid-Tech Tools	High-Tech Tools
• Pencil grips • Pens, pencils, crayons, and markers with extra-wide shafts • Raised-line paper and graph paper • Slant board • Paper holder • Nonslip surfaces • Magnetic letters, tactile letters • Bar magnifier • Rubber stamps • Sticky notes • Keyguard • Moisture guard • Head pointer/mouth pointer • Dowel (held in fist)	• Digital recorder • Calculator • Electronic dictionary/thesaurus • Audio book • Mini-book light • Switch-operated toys and small appliances • Step-by-step communicators • Inexpensive augmentative communication devices	• iPad and other mobile tablets with apps • Desktop computer • Laptop/Chromebook • iPod • "The Cloud" • Apps • Alternative inputs and outputs • Dedicated augmentative communication devices • Augmentative communication apps on iPads

Examples of modifications to off-the-shelf products include adding wooden blocks to the pedals of a tricycle so that a child who has short legs can reach the pedals, building up the handle of a pencil or eating utensil with foam so that a child with poor motor skills can grip and manipulate it better, and using a special mounting system to mount an iPad to a desk so that a child who has behavior problems can use the iPad to learn new academic skills.

Customized assistive technology devices include a wide variety of items. Communication boards created with pictures, talking dedicated devices that serve as augmentative communication systems, and communication apps for iPads are usually customized for each individual student. Teacher-made, computer-based, or mobile device-based activities to teach specific skills are other examples of customized assistive technology devices.

As you can see from these examples, the definition of assistive technology devices is quite broad. A helpful way of organizing all of these possibilities is to place them on an assistive technology continuum—that is, a continuum from low tech to high tech (see Figure 1.2). Low-tech devices have no electronic components and are inexpensive. They are what are often called "gadgets," "gizmos," "doodads," or "thingamajigs"—that is, simple tools that make daily tasks easier.

The kitchen is a good place to find examples of low-tech devices. Can openers and jar openers with thick handles make opening cans and jars easier for people with limited strength. Color-coded measuring spoons with big numbers help people with low vision choose the correct measuring spoon. Cookbook holders hold open the pages of a cookbook to the correct recipe so the cook can refer to it easily. In the classroom, typical low-tech devices include pencil grips that improve a student's handwriting by building up the shaft of a pencil (see Figure 1.3), clipboards to hold papers steady, masking cards to help struggling readers keep their eyes on a line of text, and simple communication boards made out of pictures.

High-tech devices are items that are based on sophisticated technology. These powerful and flexible devices can be used for many tasks, rather than a single task. For example, computers (desktops or laptops) and mobile devices connected to the Internet and equipped with specific apps can be used for writing, reading, information gathering, correspondence, creative expression, and learning new skills. Sophisticated augmentative communication systems—whether dedicated or based on an iPad app—can be used for these same tasks, with the important addition of providing a voice for students who cannot speak.

In general, high-tech devices are more complicated to operate than low-tech and mid-tech tools, and may require more training. In the past they were considerably more expensive, but with the advent of relatively inexpensive Chromebooks, mobile tablets, and various apps, their higher cost is no longer a defining feature.

In between sophisticated high-tech and nonelectronic low-tech devices are items classified as mid-tech devices. Mid-tech devices are electronic in nature but are less expensive than high-tech devices and tend to be focused on a single task. Digital recorders for recording teachers'

To see the possibilities, watch Microsoft's 2014 Super Bowl commercial:

https://youtu.be/O1xgdcUWHcI

To learn more about low-tech devices, watch *Assistive Technology: Opening Doors to Independence*:

https://youtu.be/x2G1U6U3zh8

FIGURE 1.3 A pencil grip is an example of a low-tech writing tool.

lectures and handheld electronic dictionaries and spell-checks are examples of mid-tech devices. Oversized calculators and calculators that talk are other examples. Decisions about selecting appropriate assistive technology for students should always consider the entire scope of the low-tech to high-tech continuum.

Before leaving our discussion of IDEA's definition of assistive technology devices, it is important to note that the law includes an exception: "The term [assistive technology device] does not include a medical device that is surgically implanted, or the replacement of such device" (IDEA 2004, Sec. 1401(1)(B)). Implanted devices include feeding tubes for students who cannot eat and cochlear implants for students who are deaf.

The second part of IDEA's definition of assistive technology identifies assistive technology services. *Assistive technology service* refers to "any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device" (IDEA 2004, Sec. 1401(2)). Assistive technology services include evaluating a child for assistive technology; purchasing or leasing an assistive technology device for a child; customizing a device to meet a child's specific needs; repairing or replacing a broken device; teaching the child to use the device; and providing training for professionals, family members, and other individuals who are "substantially involved in the major life functions" of the child (IDEA 2004, Sec. 1401(2)(F); see also Figure 1.1). The inclusion of assistive technology services in the law is extremely important because it recognizes that simply *providing* a device is not enough. Making a device available without providing essential supports is a major barrier to the successful implementation of assistive technology. This concept will be discussed in detail in Chapter 14.

Related Terms

Other terms are sometimes used to refer to technology that has been designed for individuals with disabilities. The meanings of *rehabilitation technology*, *special education technology*, *educational technology*, *instructional technology*, and *information technology* often overlap and may represent different things to different people (Golden, 1998). Because this book's focus is on teaching and learning in the classroom, our use of the term *assistive technology* refers primarily to technology that meets the *learning and communication needs* of children and youth with disabilities in school. We use *assistive technology* to refer to any kind of technology (low tech to high tech) that helps students with disabilities succeed in school, whether it involves a device that is specifically designed for people with disabilities or one that is based on a mainstream product. (A more thorough discussion of this "definitional ambiguity" [Golden, 1998, p. 6] is found in this text's preface.)

THE LEGAL BASIS FOR ASSISTIVE TECHNOLOGY

As noted in the previous section, the definition of *assistive technology* is specified in federal special education law. IDEA 2004 includes this definition because the law mandates that assistive technology devices and services be provided to students with disabilities *if the technology is essential for accessing education and education-related resources*.

Individuals with Disabilities Education Act

Although IDEA 2004 is the most recent reauthorization of the federal law that governs the education of students with disabilities in P–12 settings, it was the 1997 reauthorization that changed the role of assistive technology. Reauthorizations of IDEA prior to 1997 mentioned assistive technology only in provisions related to supplementary aids and services. As a result, consideration of assistive technology was typically limited to students with severe disabilities. The reauthorization of IDEA in 1997 dramatically changed this situation by clearly defining assistive technology and requiring *consideration* of the assistive technology needs of *every* student receiving special education services. IDEA 1997 adopted the definition of assistive technology established by the Technology-Related Assistance for Individuals with Disabilities Act of 1988 (Tech Act). (See Figure 1.4 for a brief timeline.) By inserting assistive technology consideration into every individualized education program (IEP) *development* process, IDEA 1997 significantly increased the number of students, as well as the range of disabilities, for which assistive technology solutions are now considered. Note, however, that the law does not state that all

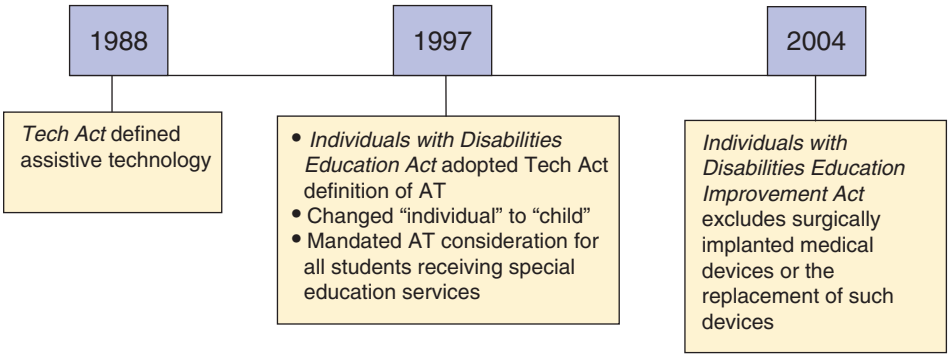


FIGURE 1.4 **Brief timeline of assistive technology law.**

students with disabilities are *entitled* to assistive technology—only that assistive technology be *considered* when their IEP is developed.

IDEA 2004 alters only slightly the 1997 definition of assistive technology by specifically excluding surgically implanted medical devices or replacement of such devices. Assistive technology consideration remains one of the "special factors" that must be considered during the development of the IEP. IDEA 2004 reiterates the importance of assistive technology in the education of students with disabilities by giving priority status to funding "projects that promote the development and use of technologies with universal design, assistive technology devices, and assistive technology services to maximize children with disabilities' access to and participation in the general education curriculum" (Sec. 1481(d)(4)(6)).

In addition to IDEA 2004, two other federal laws have had an impact on the provision of assistive technology to students with disabilities. Section 504 of the Rehabilitation Act of 1973 (and subsequent reauthorizations) and the Americans with Disabilities Act (ADA) of 1990 ensure that students with disabilities have equal access to education and that they are protected from discrimination based on having a disability. Each of these laws has relevance to our discussion of assistive technology.

Section 504 of the Rehabilitation Act of 1973

Section 504, which has been reauthorized several times since its original passage, states the following:

> No otherwise qualified individual with a disability in the United States … shall, solely by reason of her or his handicap, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance. (Sec. 794(a))

As recipients of federal funds, school districts must comply with Section 504. Because it is a civil rights provision, Section 504 applies to a broader range of students than those who fall within the 13 categories of disabilities specified by IDEA 2004. Section 504 applies to *all* students with disabilities, even those who are not eligible for special education. Students with medical conditions such as heart malfunctions, blood disorders, chronic fatigue syndrome, respiratory conditions, epilepsy, and cancer would be considered to have a disability and are entitled to accommodations under Section 504 if the condition impacts their education (Utah State Office of Education, 2011). They are entitled to educational accommodations so they will not be denied an education equal to that provided for their typical peers. Therefore, students who are considered to have a disability under Section 504 may be entitled to assistive technology to avail themselves of educational opportunities.

Americans with Disabilities Act

The Americans with Disabilities Act is civil rights legislation aimed at preventing discrimination against individuals that is based on disability. The ADA extends civil rights protection to public places, including educational institutions, places of employment, transportation, and

Section 508

A second part of the Rehabilitation Act is also relevant to our discussion of technology for people with disabilities. Section 508 recognizes the importance of people having access to information technology, so it requires all federal agencies to make their websites and computer systems accessible to people with disabilities and to purchase only those equipment items that provide such access. The law specifies that information technology "includes computer hardware, software, networks, and peripherals as well as many electronic and communications devices commonly used in offices" (U.S. Department of Education, n.d.). Although Section 508 applies only to federal agencies, its impact has been significant because it has encouraged the development of accessible technologies. As a result, many barriers to accessing information technology are being eliminated.

communication services, whether or not the institution or business receives federal funds. With respect to education, the ADA is especially important for students pursuing postsecondary education because these students are no longer covered by IDEA. Assistive technology is not specifically mentioned in the ADA, but it is generally considered to fit under the phrase "auxiliary aids and services" that must be provided to make programs accessible. Many colleges and universities provide assistive technology as a reasonable accommodation to make their programs accessible to students with disabilities. Chapter 15 provides more detailed information on college students' rights under the ADA.

Watch Bob Williams, disability activist, speak on the 20th anniversary of the passage of ADA:

https://youtu.be/fLg533x8vKE

National Education Technology Plan

In addition to the laws specific to disability, two national developments in the world of education reform relate closely to the goal of using technology to increase participation, productivity, academic achievement, and independence: the National Educational Technology Plan (NETP) and the Common Core State Standards. In 2010, the U.S. Department of Education released a report called *Transforming American Education: Learning Powered by Technology* (U.S. Department of Education, Office of Educational Technology, 2010). This plan, which is part of the Obama administration's goal of closing the achievement gap, "recognizes that technology is at the core of virtually every aspect of our daily lives and work" and declares that "we must leverage it to provide engaging and powerful learning experiences" (p. ix). The first goal of the National Educational Technology Plan is "Learning: Engage and Empower." Goal 1.3 is particularly relevant to assistive technology:

> States, districts, and others should develop and implement learning resources that exploit the flexibility and power of technology to reach all learners anytime and anywhere … When combined with design principles for personalized learning and Universal Design for Learning, these experiences also can be accessed by learners who have been marginalized in many educational settings: students from low income communities and minorities, English language learners, students with disabilities, students who are gifted and talented, students from diverse cultures and linguistic backgrounds, and students in rural areas. (p. xvi)

Common Core State Standards

In 2009, the Council of Chief State School Officers (CCSSO) and the National Governors Association Center for Best Practices (NGA Center) began an initiative to address the problem of too many U.S. high school graduates not being adequately prepared for college. The result of their collaboration was the development of Common Core State Standards (CCSS) in mathematics and English language arts/literacy. These standards articulate "what a student should know and be able to do at the end of each grade" (Common Core State Standards Initiative, 2014a). They have since been adopted by 43 states, the District of Columbia, four territories, and the Department of Defense Education Activity.

A fundamental goal of the CCSS is to "promote a culture of high expectations for all students" (Common Core State Standards Initiative, 2014a). This is particularly relevant language for students with disabilities since historically many have been limited by teachers' low

expectations. Moreover, the CCSS recognizes that these students will need additional "supports and accommodations" to meet the standards. The CCSS document specifically mentions the need to provide "instructional support for learning—based on the principles of Universal Design for Learning" and "assistive technology devices and services to ensure access to the general education curriculum and the Common Core State Standards" (Common Core State Standards Initiative, 2014b). Poss (2014) points out that "applying the principles of UDL supports students in achieving the rigors of the Common Core" (p. 23).

BRIEF HISTORY OF ASSISTIVE TECHNOLOGY

Before the passage of the laws discussed previously, there were no legal mandates to provide assistive technology to students with disabilities. However, a few people recognized the value of what we now call low-tech devices. The manual typewriter was one of the first pieces of technology adopted by people who could not write due to a disability. The first typewriter was developed in 1808 by a man named Pellegrino Turri, who built it for his friend Countess Carolina Fantoni da Fivizzono, who was blind, to help her write legibly (Jacobs, 1999). In more recent times, Bob Williams, a disability rights advocate who has physical disabilities and cannot speak, identifies a typewriter as his first piece of technology. He was 7 years old when his parents provided him with an IBM electric typewriter. He learned years later that his teacher had not believed he would ever learn to read. His reflection on this first piece of technology provides important insights:

> I am convinced that had I not had the typewriter, my teacher's perception would have likely become very much of a self-fulfilling prophecy. I would have become, like an estimated 50% of my contemporaries with cerebral palsy who, despite their typical intelligence, now face significant difficulties with reading, writing, and comprehending much of the printed word. (Williams, 2000, p. 247)

View writer Michael Williams' presentation on his personal history with augmentative technology, *How Far We've Come, How Far We've Got to Go: Tales from the Trenches*:

https://youtu.be/f14uio_2tNk

Fast-forward to the early 1980s, when the first affordable personal computers became available. The ability to delete and insert text without having to retype entire pages was quickly recognized as a powerful feature by problem solvers like Bob Williams. Peripherals that turned PCs into talking machines for people who could not speak quickly followed. The first book on this topic, *Personal Computers and the Disabled*, was published in 1984 (McWilliams) with illustrations of the latest computers such as Hewlett-Packard's HP-150, which, for a mere $3,995, came with a 9-inch green screen and 256K of memory (256 *kilo*-bytes, not gigabytes). The Radio Shack TRS-80 was $1,999 and featured a 12-inch screen but had only 64K of memory. Texas Instruments marketed one of the first "portable" computers—it cost $2,695, had 128K of memory, and weighed *only* 37 pounds (44 pounds with a color monitor)!

Technology enthusiasts thought they saw the future: If only the technology could be faster, have more memory, weigh less, and cost less, the problems facing students with disabilities would be solved. In the introduction to his 1984 book, McWilliams (1984) predicted exactly that:

> I hope that people will soon consider providing a personal computer for certain disabilities as automatic and as fundamental as providing a wheelchair or a leader [guide] dog or a pair of crutches. … I hope there will be so much information on and action in getting personal computers to disabled people that this book will be but a minor footnote in a major campaign. … Let's just hope that what happened to word processing from 1982 to 1984 [when it went from being unknown to being a ubiquitous writing tool] is a forerunner of what will happen to personal computers for the disabled from 1984 to 1986. (p. 16)

Did McWilliams say 1986? It still has not happened in 2015! Even with the passage of the ADA and the reauthorizations of IDEA that require the consideration of assistive technology for every student who receives special education services, it still has not happened. A 2011 review of data from the National Longitudinal Transition Study 2 found that only 8 percent of 300,000 students with high-incidence disabilities reported receiving some kind of assistive technology in

the previous year (Bouck, Maeda, & Flanagan, 2011). In a 2014 study of teachers' knowledge and perceptions of assistive technology use in one large Midwestern state, fewer than one third of respondents reported that students with disabilities used assistive technology on a daily basis to access instructional materials (Okolo & Diedrich, 2014).

Through the 1990s and the first decade and a half of the 21st century, the technology *has* improved—steadily, rapidly, impressively, while the cost has dropped dramatically—yet McWilliams's prediction has not come to pass. The problems of getting technology to students with disabilities and getting the technology used effectively have not been solved. At the time of this writing, numerous assistive technology products are available, many easy to use and at affordable prices, but problems with identifying appropriate tools and implementing plans in schools remain major obstacles that keep students with disabilities from benefiting from assistive technology (Macomber, 2014).

Bob Williams (2000), the disability advocate, identifies additional barriers to assistive technology implementation—namely, society's negative stereotypes and low expectations of people with disabilities:

> Why are so many people consigned to lead lives of needless dependence and silence? Not because we lack the funds or because we lack the federal policy mandates needed to gain access to those funds. Rather, many people lead lives of silence because many others still find it difficult to believe that people with speech disabilities like my own have anything to say or contributions to make. (p. 250)

Recent Developments in Technology

The latest developments in technology that are changing the landscape of the assistive technology field are the widespread implementation of "the cloud," low-cost Chromebooks, and the proliferation of smartphones and mobile devices with touch interfaces, such as the iPad and Android devices. Cloud computing is "the use of the Internet to run applications or store data" (Sanders, 2011). In other words, instead of housing complicated applications and large data files on individual computers or devices, these are stored in "the cloud" and are simply *accessed* by devices. Use of the cloud offers several benefits to schools, teachers, and students. It allows computers and mobile devices to be lightweight and less encumbered by the need for fast computing power or a large storage capacity, thereby reducing the costs of hardware. A Google Chromebook, for example, can be purchased for $200 to $300. Relying on the cloud eliminates the problem of installing software on school computers and networks, and it enables access to both educational applications and students' documents from students' homes as well as from any school computer. For example, a student with learning disabilities who needs to use text-to-speech technology to edit his writing assignments can have access to the text-to-speech app both in the classroom and from his home computer where he typically writes his papers. Another benefit of cloud computing is that applications can be upgraded by developers without requiring schools to install new versions or re-image their computers.

See how assistive technology opened up job opportunities for Nick, a young man with cerebral palsy:

https://youtu.be/_BpVi3MS-4I?list=PLRt8N3Siu_0hK8Ev_F7QEzhqng6YFOp1t

The advent of the cloud has enabled the widespread use of mobile devices. A study by the Pew Research Center in 2013 revealed that 91 percent of U.S. adults own a cell phone, with 63 percent of them using their cell phones to access the Internet; the proportion of cell phone owners who use their phones to go online doubled from 2009 to 2013. A 2014 study by the Pew Research Center found that 42 percent of U.S. adults own a mobile tablet device (Figure 1.5). Every indication is that these percentages will continue to rise. Schools have followed suit, buying mobile devices in bulk, many before they have figured out what to do with them.

Why have smartphones and mobile devices become so popular? In addition to their relatively low cost, there are several important reasons.

First, they are very easy to use. The touch interface makes navigating around the device simple—there is no need to memorize any commands or keyboard combinations, no mouse or trackpad to learn how to use. Touching with a simple point is a lot less complicated than typing on a keyboard. As Flewitt, Kurcikova, and Messer (2014) observed in their study, "The iPad required minimal effort when compared to the precision and coordination needed for

© Photo by Amy Dell

FIGURE 1.5 This student's use of three devices simultaneously is a common sight on college campuses.

computer use, where students' attention was divided between a keyboard and a screen located in separate physical spaces" (p. 112). These authors also refer to the iPad's "comparative effortlessness." Children as young as 18 months are using their parents' iPhones (Figure 1.6; Chiong & Schuler, 2010).

Second, because smartphones and mobile devices are easy to use, the learning curve is much faster than with conventional computers, and users (both teachers and students) become comfortable using them quickly (Douglas, Wojcik, & Thompson, 2012). Students in a study in Australia noted that unlike computers, iPads fit seamlessly into their daily lives (Park & Burford, 2013).

Third, mobile devices are fast. You touch a button and the device immediately begins to work. There is no need to spend time waiting while the device "boots up" or a program opens.

Fourth, the batteries of mobile devices hold their charge for many hours—days even. In contrast, most laptop computers have to be connected to a power source after a few hours of use.

Fifth, mobile devices are lightweight and portable, easily carried in a backpack or purse. Also, because they store their files in the cloud, they can be used across multiple environments.

Sixth, mobile devices are versatile and flexible. They come with many functions built in, and hundreds of thousands of apps are available that enable users to perform a multitude of tasks.

Some of their other features make mobile devices especially attractive for students with disabilities and their teachers. First and foremost is that because they are everyday technologies that are used by millions of people, there is no stigma attached to using them (Douglas et al., 2012). Many students with disabilities previously were reluctant to use "special" technology because

FIGURE 1.6 The simple touch interface on an iPhone makes it so easy to use that even an 18 month old child can use it.

they did not want to stand out from their peers (Newton & Dell, 2011). With iPads and other tablet devices, students are not singled out and, therefore, are more likely to use them.

In addition, well-designed instructional apps promote student learning by providing immediate feedback on correct answers and corrective feedback on incorrect answers (Haydon, Hawkins, Denune, Kimener, & McCoy, 2012). The research also suggests that when used with

FIGURE 1.7 This child who has physical disabilities is accessing an iPad using a Bluetooth switch. The iPad is mounted securely on a stand because he is not able to hold it.

FIGURE 1.8 This teenager communicates using an iPad, a special case, and an augmentative communication app.

appropriate apps, iPads increase student motivation, concentration, and engagement in learning activities (Cumming & Rodriguez, 2013; Flewitt et al., 2014; Haydon, Hawkins, Denune, Kimener, McCoy, & Basham, 2012; Miller, Krockover, & Doughty, 2013). With this increase in engagement comes a decrease in reliance on adult prompts and an increase in independent work.

Students with disabilities also benefit from the accessibility features that are built in to the iOS and Android operating systems. These features allow for customizing the device to meet a student's individual needs (Rodriguez, Strnadová, & Cumming, 2013). For example, a student with cognitive disabilities, whose reading skills are weak, can set an iPad to speak aloud all text messages and e-mail (See Figures 1.7 and 1.8). A student with visual impairments can select the Increase Contrast and Larger Text features. (See Chapter 8.) A student who is blind can activate the built-in screen reader, VoiceOver.

- See iPads in special education class: https://youtu.be/So2eDnKosJc
- Meet Jean, a student with Down syndrome who is using an iPad to access the curriculum: https://youtu.be/0_n541sj9qU

FOCUS OF THIS TEXT

Whether using mobile devices, Chromebooks, or conventional computers, assistive technology has the potential to empower people with disabilities with opportunities to participate in their communities and achieve more than ever before (ATA, 2004). Technology has been called "the great equalizer" for people with disabilities because it offers "better opportunities to communicate, learn, participate, and achieve greater overall levels of independence. Perhaps most importantly, new technologies enable people with disabilities to perform competitively in the workplace" (National Organization on Disability, 2006).

Also called "electronic curb cuts," computer technologies provide access to activities and opportunities that people without disabilities tend to take for granted. In education, they can provide access to the general education curriculum and key educational experiences such as the typical reading, writing, and assessment activities that take place daily in every classroom (Dell & Newton, 2014). Providing access to the curriculum is an essential component of the successful inclusion of students with disabilities in their neighborhood schools (Nolet & McLaughlin, 2000; Salend, 2004; Villa & Thousand, 2000). Technology can enable students with disabilities to demonstrate their understanding of academic subjects even if they cannot write legibly or speak intelligibly (Male, 2003). It can make textbooks understandable to students who are poor readers (Meyer & Rose, 1998). It can decrease students' reliance on teachers and other adults by increasing students' independence in completing academic tasks (Bryant, Bryant, & Rieth,

2002; Haydon et al., 2012). Assistive technology can provide a voice for students who cannot speak (Williams, 2006). The list of benefits goes on.

However, after 30 years of exploring new assistive technology products and teaching teachers, parents, and students how to use them, the authors have reached one clear conclusion: Technology alone is not enough. The latest gizmos are undoubtedly exciting and fun to use, but a device alone will not increase a student's success in school. A school's purchase of a cart of iPads or Chromebooks will not automatically lead to student gains. November (2013, p.1) calls this approach "spray and pray:" " 'Spray' on the technology and then 'pray' that you get an increase in learning." Providing students who have disabilities with the most dazzling devices in the world will not make a difference in their lives—*unless* the initiative integrates the technology into the curriculum *and* addresses the details of implementation.

This text's emphasis, then, is on the *integration of assistive technology into the curriculum*: how assistive technology can be used in all kinds of classrooms to enhance the teaching and learning of students with a wide range of disabilities. It is easy to be seduced by the razzle-dazzle of the latest electronic gimmick, but we have tried to resist that temptation and instead have focused on the *link* between technology and the teaching-learning process. The context for our discussions of assistive technology use is always the classroom, the school, and other environments in which students learn. This approach reflects the philosophy of the leading professional organization in educational technology, the International Society for Technology in Education (ISTE): "Learning with technology should not be about the technology itself but about the learning that can be facilitated through it" (Knezek, Christensen, Bell, & Bull, 2006, p. 19).

In addition to this curriculum integration philosophy, we share the core principles of the Alliance for Technology Access, a national network of technology resource centers, organizations, and businesses that seek to connect people with disabilities to technology that will empower them to participate fully in their communities (ATA, 2004). These principles explain how technology relates to people with disabilities obtaining their basic rights:

- People with disabilities have the right to maximum independence and participation in all environments, without barriers.
- Technology can be harnessed to diminish or eliminate environmental barriers for people with disabilities.
- People with disabilities have the right to control and direct their own choices, and the right to access the information they need to make informed decisions according to their goals and interests.
- People with disabilities have the right to employ assistive technologies, strategies for implementation, and necessary training support to maximize their independence and productivity. (ATA, n.d.)

Independence, self-sufficiency, personal choice, participation, inclusion, dignity—these principles are a direct outgrowth of the disability rights movement. In the late 1960s, motivated and educated by the protest strategies and successful outcomes of the civil rights movement, a handful of college students with disabilities began their own self-determination movement in Berkeley, California (Shapiro, 1993). Calling themselves the Rolling Quads and led by Ed Roberts, a young man with severe physical disabilities as a result of polio, these students rebelled against the patronizing, controlling, and limiting bureaucracy and set out to break down "the common barriers they faced—from classrooms they could not get into to their lack of transportation around town" (p. 48). Their goals expanded to "total self-sufficiency," and eventually they founded the first independent living center in the country. The Rolling Quads wanted to be their own case managers, "so they would never again have to kowtow to a bureaucrat who controlled their funding" (p. 48). As part of that drive, they decided that they needed to change the way they thought of themselves: No longer would they be clients of the state; from now on they were "consumers of state services."

With this dramatic change in attitude, the traditional medical model of diagnosis and treatment prescribed by professionals was called into question. Shapiro (1993) explains this change:

> The medical model of disability measured independence by how far one could walk after an illness or how far one could bend his legs after an accident. But [Ed] Roberts redefined independence as the control a disabled person has over his life. Independence was measured not by the tasks one could perform without assistance but

See how assistive technology makes a difference by watching these videos:

- *Assistive Technology: Enabling Dreams:* https://youtu.be/rXxdxck8Gic
- *Connecting the Dots: My Assistive Technology Story:* https://youtu.be/Vff8thzMWAQ

> by the quality of one's life with help. … Disabled people themselves, the newly christened "independent living movement" assumed, knew better than doctors and professionals what they needed for daily living. And what disabled people wanted most of all was to be fully integrated in their communities, from school to work. (p. 51)

The continuing efforts of these and other disability activists eventually led to the passage in 1990 of the ADA. This civil rights law for people with disabilities provides the legal basis for the inclusion of people with disabilities in all walks of life, from the workplace to public places such as educational institutions. Assistive technology is a means to these ends. In line with that understanding, we believe that students with disabilities must be provided with access to the assistive technology tools that will increase their independence and participation in school. We also believe that teachers and other school personnel have a responsibility to help students with disabilities find and learn how to use these tools.

See how Sam, a college student with cerebral palsy, uses assistive technology in his life:

https://youtube/jYmfrrY4Hfk

In keeping with the philosophy of the disability rights movement, this text does not advocate the medical model of diagnosis and treatment that is accepted practice in rehabilitation fields. Instead, it advocates a decision-making process that places the student at the center (ATA, 2004). Rather than relying on "experts" to "diagnose" a problem and then "prescribe" a "treatment," the student-centered decision-making model actively engages the student with a disability and family members in a collaborative process of finding those technology tools that best meet the student's needs and preferences.

How does this consumer-directed approach fit in an educational setting? We believe that students and their parents need to be active participants in the decision-making process. They have important roles to play in figuring out which technology tools will best help them with their schoolwork and with which technology tools they are most comfortable. The selection of these technology tools must tie into the goals and dreams that students (and their parents) have. Teachers and assistive technology specialists need to ask students and parents for their input and honor their preferences during the assistive technology selection process (Bowser & Reed, 2012; Grady, Kovach, Lange, & Shannon, 1993; Moore, Duff, & Keefe, 2006).

ASSISTIVE TECHNOLOGY DECISION-MAKING PROCESS

This text introduces numerous technology tools that, when used appropriately, can significantly enhance the school experiences of students with disabilities. But with all these choices available, how does one determine which specific piece of assistive technology will help an individual student? Addressing this issue is key to successful implementation of assistive technology. The previous paragraph begins to answer the question by highlighting the importance of including students and their parents in the decision-making process. Who else needs to be included? And which components need to be considered?

The Quality Indicators for Assistive Technology (QIAT Community, 2014) identify best practices in selecting and implementing assistive technology for individuals with disabilities. The guiding principles are exemplified in the SETT Framework developed by Zabala (2000, 2005). The SETT Framework reminds us that we must always begin the selection process by focusing first on the *S*tudent. What is the age and grade level of the student? What are the student's strengths? What are the student's interests? In which skills areas is the student weak?

After we have gathered this kind of information, we need to consider the nature of the *E*nvironments in which the student spends time. What is the physical arrangement? Are there special concerns? Which equipment and materials are currently available in the environment? What is the instructional schedule? Which supports are available to the student? Which resources are available to the people supporting the student?

Learn more about *QIAT: Quality Indicators for Assistive Technology.*

https://youtu.be/UkGtctUD9P8

After we have addressed the "S" and "E" of the SETT Framework, we then need to ask which *T*asks the student must perform to be successful in those environments. Which activities take place in the environment that support the student's curriculum, and what are the critical elements of these activities? For example, in a typical fourth-grade classroom, students need to read their textbooks and assigned work; they need to complete worksheets and write short compositions; they need to participate in hands-on science activities; and they need to communicate with other students when working on group projects.

Only after the *S*tudent, the *E*nvironments, and the *T*asks have been addressed can we begin to consider specific technology *T*ools. How might technology support the student's active participation in those activities? Which strategies might be used to improve the student's performance? Which low-tech, mid-tech, and high-tech options should be considered for *this* student in *these* environments? This decision-making process will be discussed in more detail in Chapter 13, but it is introduced here to provide the reader with a practical frame of reference.

UNIVERSAL DESIGN

Another concept that is woven throughout this book is *universal design*, which supports increased independence, participation, and inclusion of individuals with disabilities in all aspects of life and at the same time maintains the dignity of the individual. Universal design is defined as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Center for Universal Design, 1997). Before a product or environment is developed and marketed, universal design recommends considering "the needs of the greatest number of possible users, [thereby] eliminating the need for costly, inconvenient, and unattractive adaptations later on" (Center on Applied Special Technology, 2006). This concept began in the discipline of architecture, then broadened to the fields of hardware and software development, and is now a key principle in instructional design.

Watch this video to learn more about the principles and practices of universal design:

https://youtu.be/pGLTJw0GSxk

Three popular conveniences clearly illustrate the concept of universal design: automatic doors, curb cuts, and captioning of television programs. Automatic doors make stores, airports, and other public spaces accessible to individuals with disabilities, but they also make those places accessible to an even broader range of people: shoppers pushing shopping carts, travelers wheeling suitcases, parents pushing children in strollers, elderly people, and others who lack the strength to open heavy doors. In sum, automatic doors benefit a wide range of people and all of them, including individuals with disabilities, can access the facilities in a dignified manner—independently, through the same entrance.

Curb cuts are another good example of universal design. Originally designed to make navigating city streets more accessible to wheelchair users, curb cuts turned out to benefit many people other than wheelchair users (Jacobs, 1999). Curb cuts are now used by workers making deliveries with hand trucks, elderly people using walkers, roller bladers and skateboarders, as well as people pulling city shopping baskets and pushing baby strollers (Figure 1.9).

Moving from the field of architecture to that of media, our third example of universal design is the captioning of television programs. Closed captioning was originally developed to enable people who are deaf to access and enjoy television shows. When its use was limited to the deaf, the technology was expensive and cumbersome to find. Today, however, captioning is built into television production because it benefits many people. As Jacobs (1999) explains:

> Television (TV) manufacturers in the U.S. will tell you that their caption decoders for the deaf wound up benefiting tens-of-millions more consumers than originally intended. As the electronic curb cut effect has shown in the past, televisions with decoders are simply better than those without. For example, captioning can enable TV viewers to: … listen to programs in silence while someone is sleeping; and listen to programs in noisy environments like sports bars.

Captioning for television and film has also become a widely used instructional tool for people who are learning English as a second language (Brann, 2014).

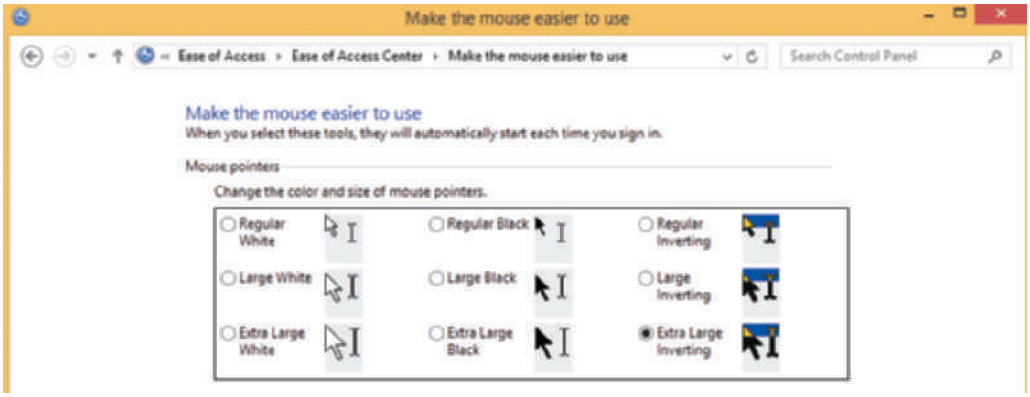
The technology industry has widely adopted the concept of universal design, particularly the principle of "flexibility in use." Wanting to sell as many computers, smartphones, and mobile devices as possible, the industry recognizes the commercial value of designing operating systems that are usable by as many people as possible. This means people who are new to a device as well as expert users, people who use their devices for enjoyment at home as well as those who use them in the workplace, and young people who have good eyesight as well as people over 40 who need reading glasses. Incorporating this concept of flexibility in use in operating systems offers several positive applications for students with disabilities.

For example, the option to have icons and text read aloud on an iPhone enables people who have vision impairments or reading disabilities to have full access to their iPhone. Being able to

FIGURE 1.9 **Curb cuts benefit people pushing strollers, hand trucks, and shopping baskets, as well as people using walkers and wheelchairs.**

use keyboard commands instead of a mouse or trackpad gives people who have fine motor difficulties an alternative means to access a computer. Designers must take into account variations among the precision, accuracy, and speed of computer users. Both the Macintosh and Windows operating systems provide the means to enlarge the size of icons and slow down the speed of the mouse (Figure 1.10). Larger icons provide a larger target area to accommodate some students' lack of precision and accuracy in directing the mouse pointer. Combined with a slower mouse speed, larger icons make it possible for some students with disabilities to use a computer without the need for additional specialized devices. For students who have hand-eye coordination problems, visual impairments, hand tremors, or cognitive disabilities, these two options are especially helpful.

FIGURE 1.10 **Mouse Cursor Choices in Windows 8.**



Source: Mouse Control Panel in Windows 8, Microsoft Corporation. Reprinted with permission.

Being able to turn on VoiceOver on iPhones and iPads is another good example of universal design. Users can navigate around their devices and use a variety of apps without having to see them. They can adjust the speed of the voice and use a series of gestures as shortcuts. They can listen to e-books using VoiceOver. iOS devices also offer the options of turning on larger text, zoom, increase contrast, speak selection, and captions.

Universal Design for Learning

Universal design for learning (UDL) draws on the concept of universal design in architecture and products and combines it with current brain research about how students learn, resulting in an approach that increases flexibility in teaching and lowers the barriers that prevent students from accessing materials and classroom activities (Rose, Gravel, & Gordon, 2014; Rose & Meyer, 2002). Just as the original concept of universal design intended to make structures and products usable by the broadest range of individuals, so UDL seeks to make curricular content available to the broadest range of students. For example, apps that provide spoken directions enable students who cannot read, students who forget directions, and students with attention problems to complete activities without teacher intervention. Digital media, especially electronic text, offer many opportunities to engage students in learning and to enable them to demonstrate what they have learned even if they struggle with traditional reading and writing tasks. This is why the Common Core State Standards recommend UDL specifically as an example of "instructional supports for learning" that are appropriate for students with disabilities. UDL makes the curriculum accessible to a broad range of students, including general education students who are auditory learners, who are visual learners, or who are difficult to engage or motivate, as well as students with disabilities. When the principles of UDL are applied in classrooms, the need for additional assistive technology solutions for individual students may be reduced or eliminated. Upcoming chapters, particularly Chapters 4 and 8, discuss UDL in more detail.

Even in classrooms where UDL is practiced, however, some students will continue to need specialized technology solutions. For example, because the number of students who are blind is comparatively small, the potential market for Braille keyboards is also small. As a result, Braille keyboards are not likely to become a standard option on conventional computers. Therefore, whereas universal design is an outstanding development for people with disabilities and remains an essential part of the assistive technology decision-making process, it does not completely eliminate the need for specialized products. Throughout this text, we will provide information on both universally designed features and specialized technology devices, with the emphasis always placed on identifying the appropriate match between students' needs and possible technology solutions.

A NOTE ON TERMINOLOGY

In the years since the first edition of this text was published, the field of assistive technology has undergone several major changes. Most relevant to this third edition is the emergence of "cloud computing," inexpensive laptops such as Chromebooks, and the proliferation of mobile tablets such as iPads and Android devices. Vocabulary used to describe technology-based products has evolved accordingly. To avoid awkward and verbose phrases, this text will use the term "app" to refer to any educational software program, whether it is accessed on a desktop computer, laptop computer, or mobile tablet, and whether it is provided on a tangible media device such as a CD, DVD, or thumb drive, or is stored "in the cloud."

A NOTE ON PRODUCT NAMES

Today, when we talk about assistive technology, we could be talking about desktop or laptop computers using the Windows or Macintosh operating system, Chromebooks using the Chrome operating system, iPads and iPhones running on iOS, or tablets and smartphones running on the Android operating system. Each of these operating systems requires apps and peripherals that have been designed specifically for it. In addition, new apps are released daily. Therefore, it is impossible for this text to provide examples of products for every different operating system. Instead, the authors have tried to describe desirable features of apps while including examples

to illustrate the points. Their intention is not to promote one brand over another. Readers are encouraged to identify similar apps that run on the operating system they are using.

CONCLUSION

Do you remember Bernie, the person profiled at the beginning of this chapter who typed on a typewriter with his foot? The dowel that was bolted to the bottom of his shoe was a good example of a low-tech device, and it served him well. But think of how much more Bernie could have written—how much more he could have interacted with the world—had he lived today and could use his low-tech dowel to access a high-tech computer with a high-speed Internet connection. As you read the following chapters, think of what Bernie could have accomplished with the technology tools that are highlighted. Think of other people you know who have difficulties writing or reading or learning or communicating. Try to make connections between their particular needs and the opportunities offered by assistive technology. You will find powerful solutions to the problems they face, and we hope you will be as excited as we are by the promise of assistive technology.

Summary

- Lessons from people with disabilities: (1) Regardless of how disabled a person may appear, inside is a person who wants to be part of life. (2) Taking a problem-solving attitude can lead to creative solutions that eliminate obstacles caused by disabilities. (3) Simple technology can change a person's life.
- Assistive technology is defined in the Individuals with Disabilities Education Improvement Act of 2004 (IDEA 2004). The definition consists of two parts: assistive technology devices and assistive technology services.
- The assistive technology continuum spans a range from low-tech to high-tech devices. Low-tech devices, such as pencil grips and clipboards, use no electronic components and are relatively inexpensive. High-tech devices, such as laptops, iPads, and augmentative communication devices, are based on computer technology and are versatile and do many things.
- The term *assistive technology* is related to several other terms—*rehabilitation technology*, *special education technology*, *educational technology*, *instructional technology*, and *information technology*. However, this text uses it to refer primarily to technology that meets the learning and communication needs of students with disabilities.
- Three federal laws have had an impact on the provision of assistive technology to students with disabilities: Section 504 of the Rehabilitation Act, the Americans with Disabilities Act (ADA), and IDEA 2004.
- The National Educational Technology Plan and the Common Core State Standards recognize the important role of technology in closing the achievement gap and improving the outcomes of students with disabilities.
- Despite these laws, serious problems remain in getting appropriate assistive technology to students with disabilities who stand to benefit from it.
- This text's philosophy: People with disabilities have the right to independence, self-sufficiency, personal choice, participation, inclusion, and dignity, and technology can be harnessed and applied to achieve these goals.
- This text's emphasis is on the integration of assistive technology into the curriculum—the link between assistive technology and the teaching and learning of students with disabilities.
- The SETT Framework provides a helpful guide for deciding which technology tools will help an individual student. This framework reminds us that we must always begin the selection process by focusing first on the *student*.
- Universal design is defined as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Center for Universal Design, 1997).
- Universal design for learning (UDL) seeks to make curricular content available to the broadest range of students.

Web Resources

For additional information on the topics listed, visit the following websites:

Overviews of Assistive Technology
http://www.edutopia.org/article/assistive-technology-resources

IRIS Center at Vanderbilt University, Modules on Assistive Technology
http://iris.peabody.vanderbilt.edu/iris-resource-locator/?term=assistive-technology

Low-Tech Tools
MaxiAids: Products for Independent Living
http://www.maxiaids.com/store/default.asp

LS&S: Products for the Visually Impaired and Hard of Hearing
http://www.lssproducts.com/resources

Assistive Technology Videos
Center on Technology and Disability
http://www.ctdinstitute.org

Laws Governing Assistive Technology
Wrightslaw
http://www.wrightslaw.com

FAQs: Section 508: Electronic and Information Technology
http://www.justice.gov/crt/508/archive/deptofed.html

History of Assistive Technology
Disability Museum: Search "assistive technology" in Library
http://www.disabilitymuseum.org

Legends and Pioneers of Blindness Assistive Technology, Part 2 by A. R. Candela American Foundation for the Blind's AccessWorld, September 2006
http://www.afb.org/afbpress/pub.asp?DocID=aw070509

Philosophy of This Text
International Society for Technology in Education (ISTE)
http://www.iste.org

Norman Kunc
http://www.broadreachtraining.com/training/schlindx.htm

Disability Rights Movement
Smithsonian's Disability Rights Movement Virtual Museum
http://www.americanhistory.si.edu/disabilityrights/welcome.html

Oral Histories of the Disability Rights and Independent Living Movement
http://bancroft.berkeley.edu/collections/drilm.html

Universal Design

Center for Universal Design at North Carolina State University
http://www.ncsu.edu/ncsu/design/cud/

Center on Applied Special Technology (CAST)
http://www.cast.org/udl/index.html

Universal Design in Operating Systems

Keyboard shortcuts in Windows operating systems
http://www.microsoft.com/enable/products/keyboard.aspx

Accessibility Features in Apple's iOS
https://www.apple.com/accessibility/ios/

Accessibility Features in Google Products
https://www.google.com/accessibility/products/

Chrome AT Tool Box 2.0
http://www.chrometoolbox.com

Suggested Activities

1. *Recognize the power of assistive technology.* Observe or interview a person with a disability who uses assistive technology in daily life. The technology could be a computer, an iPad, an Android phone, an augmentative communication device, or any low-tech or mid-tech device.
   a. *Introduce the user:* Write a paragraph introducing the person. Make him or her come alive as an individual first and foremost. Mention school or work and the person's interests. Then include some information about his or her disability.
   b. *Discuss the benefits and purpose of assistive technology use:* What does assistive technology enable this person to do? Discuss specific activities.
2. *Demonstrate low-tech assistive technology.* Visit a dollar store and find an item that could be used as low-tech assistive technology. Bring the item to class to share your idea and demonstrate its use (e.g., a clipboard to hold papers securely or rubberized shelf liner to keep books from slipping).
3. *Research universal design.* Visit the website of the Center for Applied Special Technology at http://www.cast.org. Read up on the latest research and developments in universal design for learning. Write a summary of one of them and post it to your class blog or discussion board.
4. *Start an assistive technology portfolio.* Begin gathering resources on assistive technology. The portfolio can be compiled and presented electronically using Pinterest, PowerPoint, a blog, or a website, or it can be compiled in hard copy, using a binder or accordion file. The key is to organize the materials and clearly label them. The following categories are suggestions: product flyers, standards or guidelines from your professional organization regarding assistive technology skills, and informative websites or print materials that would be useful resources for colleagues and parents. Add relevant materials to the portfolio after reading each subsequent chapter in the text.

2 ASSISTIVE TECHNOLOGY TO SUPPORT WRITING

Learning Outcomes

1. Describe the major components of the writing process.
2. Explain the kinds of problems that students with disabilities have with writing.
3. Identify technology tools that support students' prewriting activities.
4. Identify technology tools for both computers and mobile devices that address students' problems with drafting, reviewing, and editing.
5. Identify technology tools that can be used for publishing or sharing of students' work.
6. Identify technology tools that address problems with note taking.
7. Recognize the importance of providing students with training on both the technology tools and the use of those tools to improve their writing.

INTRODUCTION

Whether the assignment is answering test questions, writing book reports, composing a persuasive essay, or preparing a science lab report, students need to be able to write to be successful in school. Through their writing, students are assessed on their factual knowledge, their ability to synthesize and evaluate information, and their facility with language skills; they also use writing for additional learning (Graham & Perin, 2007). Likewise, students can express their creativity through their writing. The importance of developing strong writing skills for future success in college, career, and life in the 21st century is emphasized by the content standards for language arts reaffirmed by the National Council of Teachers of English/International Reading Association in 2012 and included in the Common Core State Standards (CCSS) that have been adopted by 43 states (Common Core State Standards Initiative, 2014). The College and Career Readiness Anchor Standards for Writing state the following:

> To build a foundation for college and career readiness, students need to learn to use writing as a way of offering and supporting opinions, demonstrating understanding of the subjects they are studying, and conveying real and imagined experiences and events. They learn to appreciate that a key purpose of writing is to communicate clearly to an external, sometimes unfamiliar audience, and they begin to adapt the form and content of their writing to accomplish a particular task and purpose. They develop the capacity to build knowledge on a subject through research projects and to respond analytically to literary and informational sources. To meet these goals, students must devote significant time and effort to writing, producing numerous pieces over short and extended time frames throughout the year. (p. 18)

Source: Common Core State Standards Initiative (CCSS). (2014). Preparing America's students for success. Retrieved July 31, 2014, from http://www.corestandards.org/standards-in-your-state/.

Many of the Common Core Standards link writing to technology—for example, "Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others" (National Governors Association Center for Best Practices, 2010, p. 18).

Before we can discuss how assistive technology can support writing, we need to define the term *writing* and consider the problems students with disabilities experience with writing. What *is* writing? Is it simply holding a pen and moving your hand from left to right to leave meaningful marks on a page? The process of physically producing text—that is, handwriting—is one aspect of writing. Forming letters correctly, forming them quickly, and aligning them properly on paper can be difficult for many students with disabilities (Broun, 2009). But what *else* is involved in the process of getting one's thoughts down on paper?

A huge body of literature addresses this question. Although it is beyond the scope of this text to present this literature in detail, a brief summary will provide a helpful context to our discussion.

Writing is a complex problem-solving activity that involves thinking, planning, and decision making, in addition to the mechanics of transcription. Flower and Hayes (1981) present a cognitive process model in which emphasis is placed on the underlying *thinking skills* involved in writing. They characterize the act of writing as consisting of three major elements—the task environment, the writer's long-term memory, and the writing process itself:

> The task environment includes all of those things outside the writer's skin, starting with the rhetorical problem or assignment. … The second element is the writer's long-term memory in which the writer has stored knowledge, not only of the topic, but of the audience and of various writing plans. The third element … contains writing processes themselves, specifically the basic processes of Planning, Translating, and Reviewing. (p. 369)

The process Flower and Hayes (1981) call "planning" has come to be known as **prewriting**. This process takes place before any sentence is put on paper. Prewriting involves planning for writing; generating ideas, which may include brainstorming activities and/or collecting relevant information; organizing the ideas into some kind of meaningful structure and sequence, which may take the form of a concept map or outline; and setting goals for the composing activity. Tompkins (2000) suggests that 70 percent of writing time should be spent on these prewriting activities. *Writing Next* (Graham & Perin, 2007), a study for the Carnegie Corporation on effective strategies to improve instruction in writing, identified prewriting activities as one of 11 elements of effective writing instruction.

The second process, translating, is usually referred to as **drafting**. In this process, students develop their ideas and thoughts into meaningful words, sentences, and paragraphs (Scott & Vitale, 2003). Drafting requires both thinking and mechanical processes such as handwriting or keyboarding.

In the third process, **reviewing**, students *reread* and *evaluate* what they have written. In the fourth process, **editing**, they *edit* and *revise* their drafts. These self-evaluations, edits, and revisions focus on all aspects of writing—spelling, grammar, organizational structure, word choice, and content.

Although at first glance these concepts may look like an ordered sequence, it is important to recognize that this is actually an iterative process. Good writers continually generate new ideas; reorganize their thoughts; and set new goals as they compose, edit, and revise (Flower & Hayes, 1981). The writing process, then, is more like a series of interconnected loops than a straight line. This recursive nature of the writing process has important implications for the teaching of writing (Lipson, Mosenthal, Daniels, & Woodside-Jiron, 2000) and for the use of technology to enhance writing.

Once the writing process is completely finished (usually after multiple drafts and revisions), a fifth and culminating activity is **sharing** the final product with others, or **publishing** it. Publishing can be done in a variety of ways, such as via conventional bulletin board displays or digitally through postings online on class websites, blogs, or wikis. The purpose of publishing is to provide a specific audience for the writing and "to instill pride of authorship" in student writers (Scott & Vitale, 2003).

PROBLEMS THAT STUDENTS WITH DISABILITIES HAVE WITH WRITING

Students with disabilities often have difficulty with *all* of the processes previously described (MacArthur, 2009), and it is not uncommon for them to try to avoid any kind of writing assignment. "I don't like to write. It's hard and it hurts my brain to think so hard," wrote a student in a journal that was part of a research study on struggling writers (Tompkins, 2002, p. 179). Another student in Tompkins's study said, "When I have to write, I'm thinking about being done because I really don't like to write" (p. 179). Students with learning disabilities and attention deficits, in particular, find the writing process overwhelming. In their research on the perceptions of students with language and learning disabilities (LLDs) about instruction in the writing process, McAlister, Nelson, and Bahr (1999) found that "students with LLD may not plan because they do not know how to plan" (p. 170). The students in their study could not articulate what it means to plan or why they should plan. One interviewee said, "I just do [planning] in my head, and sometimes I just type words out, and it becomes a story." These researchers summarize writing samples of students with LLD as being "shorter, less coherent, and less refined" than those of normally achieving students (p. 160). Other experts have characterized their writing as "lifeless" (Baker, Gersten, & Scanlon, 2002).

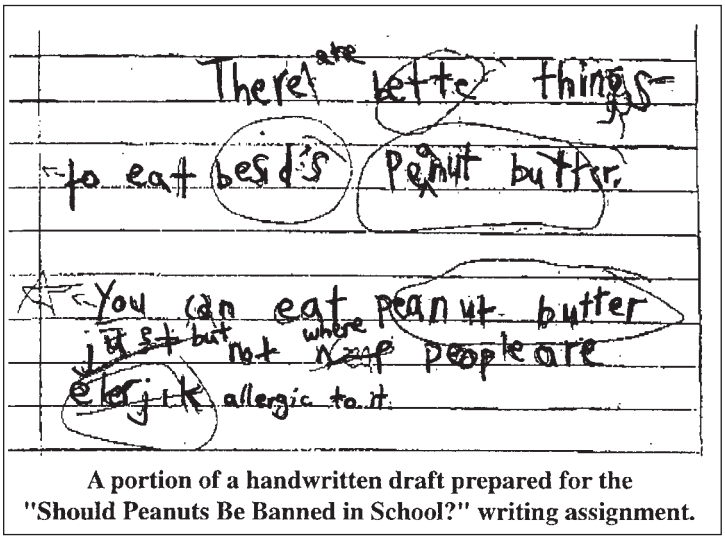
Spelling is particularly troublesome for students with learning disabilities. Their writing is often filled with misspelled words that are not corrected because students with learning disabilities have difficulty detecting the spelling errors in their writings (Darch, Kim, Johnson, & James, 2000; Jones, 2001). MacArthur, Ferretti, Okolo, and Cavalier (2001) summarize the writing problems displayed by students with learning disabilities:

> Their revisions are limited primarily to correction of mechanical errors. … They experience difficulties with transcription processes, both spelling and handwriting, and these struggles affect the overall quality of their writing because cognitive resources devoted to transcription are not available for higher-order processes. … Students with writing difficulties are also less knowledgeable about criteria for good writing and about writing strategies. … Their written products, in comparison to those of their normally developing peers, are typically shorter; contain more errors in spelling, punctuation, and capitalization; lack organization; are less cohesive; omit important genre components; and are lower in overall quality. (p. 288)

Students with other kinds of disabilities may also face obstacles when writing. Students who are deaf and communicate primarily through sign language have literacy levels well below grade level because English represents a second language for them (sign language is their first language). Students with cerebral palsy, muscular dystrophy, and other physical disabilities struggle with the mechanics of writing. They cannot hold a pencil or do not have the fine motor skills needed to manipulate a pencil. Students with emotional and behavioral disabilities often struggle with writing because they do not have the self-regulation that is needed for writing (Mason, Kubina, & Hoover, 2013); they "lack the requisite academic skills and behavioral self-control to remain engaged in academic tasks" (Haydon, Hawkins, Denune, Kimener, & McCoy, 2012).

Other students, including many with autism or learning disabilities, may be able to hold a writing implement but struggle with forming letters correctly, forming them quickly, and aligning them properly on paper (Broun, 2009). These students may have lots of ideas but cannot get their thoughts on paper, and their handwriting is often illegible (see Figure 2.1). They often "focus more energy on the handwriting process than on thinking about the content and the quality of [their] response" (Broun, 2009, p. 15). They tend to write as little as possible to avoid the frustration of writing by hand. Not only are such students unable to share their final products with others, but they also find their own handwriting difficult to decipher, making the rereading and revising process impossible. In addition, for many students on the autism spectrum, struggling with the mechanics of handwriting can be frustrating and stressful and can lead to behavior problems (Broun, 2009).

FIGURE 2.1 **A sample of the penmanship and spelling problems of a 4th grader who has learning disabilities.**



A portion of a handwritten draft prepared for the "Should Peanuts Be Banned in School?" writing assignment.

Source: Taneja, K. (2000). Alpha Smart a success in inclusive classroom. *TECH-NJ, 11*(1), 4. Used by permission.

One final problem related to writing faced by many students with disabilities is note taking. Taking notes, which is an essential activity in many educational situations, is a specialized form of writing. Many students who have learning disabilities miss important points and "produce notes that are incomplete, incoherent, or ineffectively organized" (Belson, Hartmann, & Sherman, 2013, p. 14). This further disadvantages them when they need to study for a test. Note taking requires the ability to listen and write at the same time, the ability to organize the ideas that are presented, and the ability to distinguish what is important from what is not—all carried out simultaneously and speedily. Not being able to take notes is a serious obstacle to learning for students with disabilities, and they need to be taught specific note-taking strategies (Belson et al., 2013).

TECHNOLOGY TOOLS THAT SUPPORT THE WRITING PROCESS

A study by the Pew Research Center's Internet and American Life Project (Purcell, 2013) indicates that teachers believe that digital technologies "have become helpful tools for teaching writing to middle and high school students" (n.p.). In this section we will present different kinds of technology tools that can support students with disabilities through the five stages of the writing process.

Low-Tech Adaptations for Writing

Low-tech solutions may be all that a student needs, or they may be just one part of the solution for handwriting difficulties. For students who have barely legible handwriting, several low-tech items can improve their ability to manipulate a pencil and write legibly. For example, building up the shaft of a pencil with modeling clay, foam, or a commercially available pencil grip can help a student control the pencil better. Sometimes placing the paper on a slant board (at a 15- to 30-degree angle) provides better control. Students who have use of only one hand can sometimes benefit from anchoring the paper on a clipboard. Paper that has raised lines or bold lines can help students—both those with learning disabilities and those with visual impairments—stay on the lines when writing. Students who are blind need to be taught to use signature guides, which are small plastic cards that have a cutout the size of a typical signature.

Other low-tech solutions are available for students who cannot manipulate a pen or pencil at all. Some students who have a whole-hand grasp can use rubber stamps for certain writing activities. For example, number and operation sign stamps can be used for simple arithmetic worksheets. Having a stamp made with a student's name can enable a student with

Search "low tech assistive technology" on Pinterest to discover unique ways to adapt everyday products into helpful tools:

http://www.pinterest.com

physical disabilities to sign his or her name. Rubber stamps with a wide variety of pictures are available in craft stores and could be used to answer questions on worksheets or quizzes. These are all examples of easy-to-use, inexpensive items that can support the activity of writing.

Prewriting: Graphic Organizers

Most writers, both professional and amateur, feel at least some apprehension when faced with a blank piece of paper or a blank computer screen (optimistically called a "new document"). How can students get past this hurdle?

Remember that the writing process does not begin with drafting. Rather, it begins with prewriting activities such as brainstorming and getting organized. Even before computer technology, teachers discovered that using diagrams called *graphic organizers* could help students in the planning process. Sometimes called *think sheets* (Englert, Raphael, Anderson, Anthony, & Stevens, 1991), these prewriting activities encouraged students to think about what they wanted to write and helped them organize their ideas into a logical order. Now with computers and mobile devices, graphic organizer apps offer students a seamless connection between a diagram that shows the relationship among ideas (*concept map*) and a text outline (Figure 2.2). When using these tools, students no longer have to copy their ideas from the concept map to their paper or word processing document. Instead, they can spend their time thinking about their ideas and manipulating their graphical representation on a screen, and then—with one click of the mouse—they can turn their concept map into a text outline.

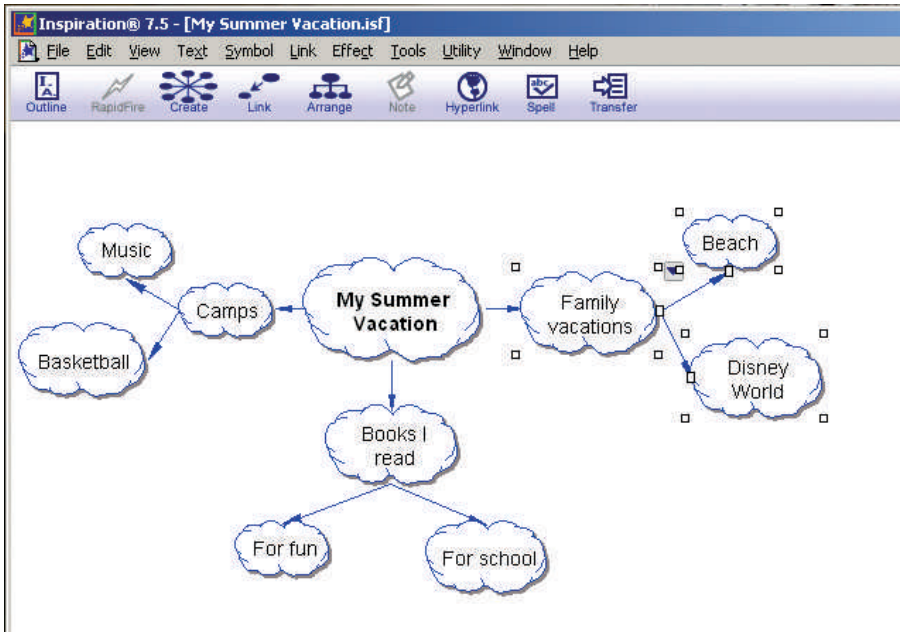
Watch this video to learn more about graphic organizing technology tools:

https://youtu.be/JQjr3LK2yT4.

Templates are particularly helpful for students with learning disabilities or attention deficits. These premade graphic organizers provide a structure for specific writing genres. When the template provides the necessary organization, the student is free to concentrate on filling in the correct content. Table 2.1 lists sample templates provided in Inspiration.

For example, in science classes students usually have to write lab reports. Students with learning disabilities or attention deficits often fail to demonstrate their understanding of the lab activity because their lab reports are disorganized and poorly written. With the science lab template that is provided in Inspiration, these students are able to enter the information in the correct

FIGURE 2.2 Sample graphic organizer: Concept map to help a student get organized for an essay on "My Summer Vacation." Clicking on the Outline icon on the toolbar converts the diagram to a text outline for further development.

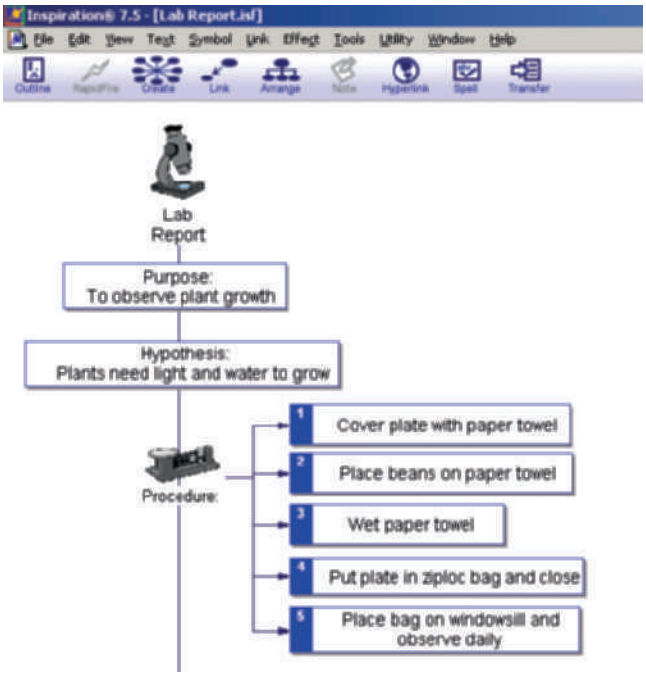


Source: Diagrams created in Inspiration® by Inspiration Software, Inc. All rights reserved. Used by permission.

TABLE 2.1 Sample Templates Provided in Inspiration

Subject Matter	Template Title
Language arts	Literary Web
	Literary Analysis
	Persuasive Essay
Science	Lab Report
	Scientific Method
	Simple Cycles
Social studies	Cause and Effect
	Historical Period
	Pro and Con
Planning	Assignment Plan
	Research Strategy
	Goal Setting
Thinking skills	Analogy
	Comparison
	Venn Diagram

FIGURE 2.3 Part of Inspiration's science lab template.



Source: Diagrams created in Inspiration® by Inspiration Software, Inc. All rights reserved. Used by permission.

place, click the "Outline" button, and create an organized text outline from which they can finish the lab (see Figure 2.3).

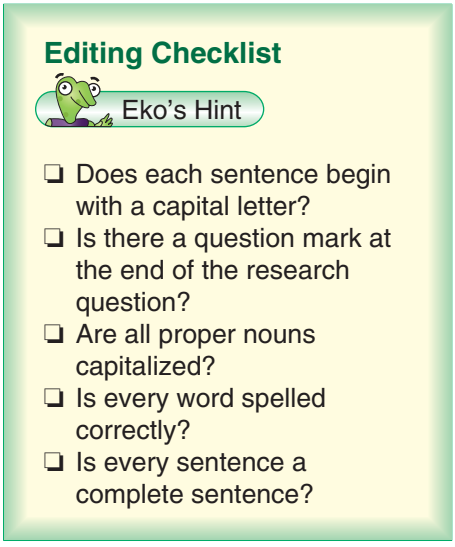
The benefits of using visual concept maps are supported by both cognitive learning theory and the research. Graphic organizers have been shown to improve students' outlining and writing skills, and to help students with learning disabilities organize information (Inspiration Software & Institute for the Advancement of Research in Education, 2003; James, Abbott, & Greenwood,

Science Writer from CAST

The CAST Science Writer (http://sciencewriter.cast.org) is a free, web-based program that offers several technology tools to support the writing process, from prewriting through editing. It begins with a prewriting tool called a "Report Structure," which helps students plan their science lab report. Prompts are provided to remind students of the kinds of information they should be entering in each section. For example, when writing a research question, a student receives the following prompt: "Scientific Inquiry begins with a question about the research you will conduct. Write one or two sentences in the form of a question. Focus on the purpose of your research" (CAST Science Writer, 2009). The website then provides scaffolds for drafting, revising, and editing, including a dictionary and a text-to-speech option. A "Help Me Get Started" button suggests "sentence starters" for different parts of the report. Three animated characters provide examples and tips if a student needs additional help, and checklists are available to remind students to check for typical errors (see Figure 2.4). Designed for middle school and high school students, CAST Science Writer is an all-in-one-package of technology-based writing supports.

2001). Computer-based concept maps offer additional advantages (MacArthur, 2009): They are easily revised and expanded; they can include prompts from a teacher that can be hidden when not needed; and most importantly, they can be converted to a text outline with a single mouse click. Thus the transition from prewriting to the next stage—drafting—is seamless.

FIGURE 2.4 Editing checklist from CAST Science Writer.



Drafting

Technology has been helping people get their ideas down on paper since the invention of the typewriter in the 1800s. (The first commercial typewriter appeared on the market in 1874, and electric typewriters became available in the 1950s.) You could say that the typewriter was the first high-tech writing tool used by individuals with disabilities. Michael Williams, a writer and disability advocate who has cerebral palsy, identifies his grandfather's standard manual typewriter as his first piece of assistive technology. He used typewriters to communicate all through grade school, high school, and college (Williams, 2006).

Bob Williams (no relation to Michael Williams), who held administrative positions in the U.S. Department of Health and Human Services during the Clinton administration, also identifies the typewriter as his first piece of writing technology (Williams, 2000), as mentioned in Chapter 1. Unable to control his fingers due to cerebral palsy, he pressed the typewriter's keys by grasping a small dowel in his fist. Dick Boydell, an Englishman with cerebral palsy who could not use his hands at all, taught himself to type using his big toe. (See Chapter 9 for a discussion of alternative access methods for students who cannot use a standard keyboard.)

WORD PROCESSING APPS: These three individuals illustrate the first solution offered by technology: the ability to create clear, legible text by students who do not have the motor skills to grasp a pencil or the fine motor coordination to master the mechanics of penmanship. This, of course, is accomplished through the use of **word processing apps** such as Microsoft Word, Google Docs, and iPad apps such as ClaroSpeak, WriteOnline and Voice Dream Writer. Even the simplest document created in these applications is neat in appearance and legible. There are no smudges or tears in the paper where the writer had tried to erase a phrase. There are no messy cross-outs or arrows going in every direction to indicate changes in the order of sentences or paragraphs. Richard Wanderman (2000), a leading educational technology consultant who has learning disabilities himself, explains why he embraces word processing for composing: "Being able to make perfectly formed letters by hitting a key is a lot easier than struggling to write by hand." MacArthur (2009) observes that "there is substantial student resistance to frequent revision when recopying is needed" (p. 246).

Seven Ways Word Processing Helps Developing Writers

1. Legibility of text
2. Potential for publishing in a variety of formats
3. Ease of revision
4. Fluent production of text (while composing or note taking, for example)
5. Likelihood of supporting applications (for spelling, grammar, or concept mapping, for example)
6. Portable, easy-to-replicate electronic text (easy to share, hard to lose)
7. Potential links to electronic source material

Source: Graham, S. (2008). The power of word processing for the student writer. Renaissance Learning. Retrieved February 10, 2015, from http://doc.renlearn.com/KMNet/R004215628GH546B.pdf. Renaissance Learning Inc. Used by permission.

When viewed in the context of the writing process, you can see that word processing apps support the generative nature of writing. The tasks of inserting new text, deleting unwanted text, and replacing text through cut-and-paste commands become effortless, allowing writers to change their minds about sentence constructions and idea development without penalty (MacArthur, 2013). There is no drudgery involved in recopying. Quoting Wanderman (2000) again:

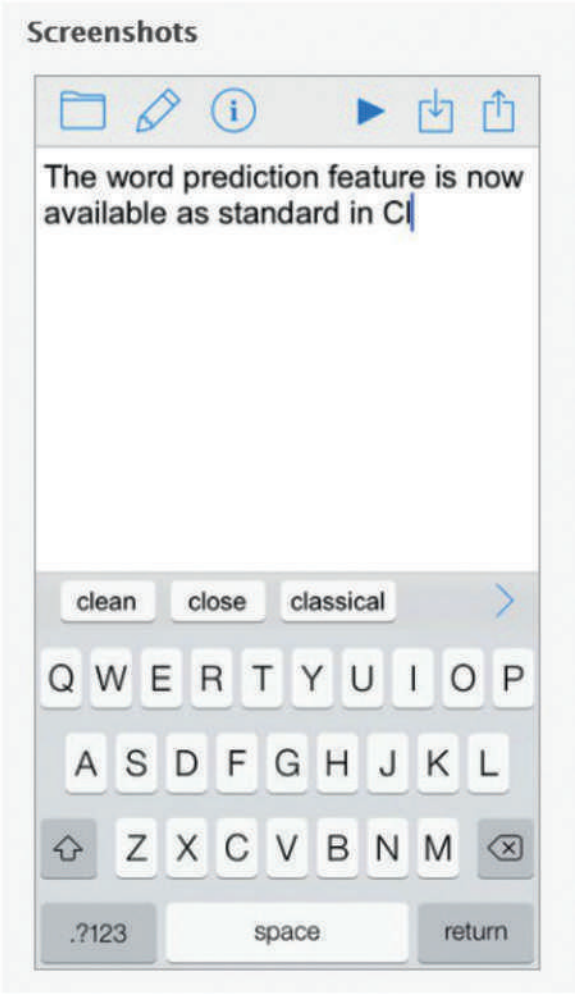
> Just being able to change things without a rewrite frees us from worry about making mistakes. With the ability to change things comes:
>
> - No emphasis on spelling during composition
> - Less emphasis on getting the ideas in the right order the first time
> - More emphasis on content …
>
> Being able to concentrate on what you are trying to say rather than struggling to get the spelling right, or worse, choosing only words you know how to spell, is what electronic editing allows.

These anecdotal comments about the benefits of word processing are supported by the research. A landmark report from the Carnegie Corporation, *Writing Next* (Graham & Perin, 2007), cites the use of word processing as one of 11 elements of writing instruction that have been found to be effective in helping adolescent students—especially low-achieving students—learn to write well.

KEYBOARDING: For students to become proficient at word processing, they need to develop some keyboarding skills (MacArthur, 2013). Keyboarding is mentioned specifically in the K–5 and 6–12 Writing Standards that are part of the Common Core State Standards for English, Language Arts, and Literacy (CCSS, 2014). For example, grade 4 students are expected to "demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting" (p. 21). Grade 6 students need to "demonstrate sufficient command of keyboarding skills to type a minimum of three pages in a single sitting" (p. 43).

Typing is very different from handwriting and requires a different set of skills. Students do not need to become fast touch typists. Rather, they need to become familiar with the locations of the letters on the keyboard so they can quickly locate the keys they desire. Keyboard familiarity means knowing where the keys are located and being comfortable with the correct placement of the hands. At a minimum, students can be taught to use their thumbs on the space bar and their pinky fingers on the shift key. There are many apps available that provide game-like activities for the teaching of keyboarding, such as http://www.bbc.co.uk/schools/typing and http://www.uberdownloads.com. The iPad app Keyboard Fun is designed specifically for children at the emergent literacy level—that is, children who are first learning how to read and spell. Because early reading usually focuses on lowercase letters, the app uses lowercase letters. The following websites provide reviews of popular typing programs for children: http://typing-for-kids-software-review.toptenreviews.com and http://www.superkids.com/aweb/pages/reviews/typing.

FIGURE 2.5 Toolbar for ClaroSpeak.



Source: ClaroSpeak App, Developer: Claro Software Limited © Claro ATG Ltd. https://itunes.apple.com/gb/app/id845128025, Claro Software Ltd www.clarosoftware.com. Used by permission.

WORD PROCESSING WITH TEXT-TO-SPEECH: In addition to taking advantage of standard word processing apps, many students with disabilities may benefit from a **text-to-speech** feature. Text-to-speech reads aloud whatever a student types; it is available in apps on most platforms—for both computers and mobile devices. This capability can read aloud word by word, sentence by sentence, or entire paragraphs or documents. The "reading chunk" feature is easily set by the user from a menu or submenu. Likewise, the speed of the reading and the quality of the voice can be easily adjusted. "Just being able to hear your writing read aloud is enough … to allow some writers to hear problems in their syntax or even spelling where they might not be able to see them" (Wanderman, 2000). A study of college students with learning disabilities using text-to-speech supports this idea that the feature can help students find errors in their writing on their own (Raskind & Higgins, 1995).

Figure 2.5 shows the toolbar for ClaroSpeak. Note the "play" button on the top right, which is the "read aloud" icon.

In addition to obtaining the accessories needed to support mobile devices, such as keyboards and stands, schools that are using mobile devices for writing must plan and implement a "digital workflow system." Workflow in schools refers to "the process of distributing assignments, retrieving student work, giving feedback, seeing revised work, essentially generating a loop of interaction between students and teacher" (St. Matthew's Parish School, n.d.). Most writing apps include a feature to e-mail or send a document via text message; the apps mentioned in the "Mobile Devices as Writing Tools" sidebar also offer the ability to upload a document to Google Docs and/or Dropbox. Although these features solve the problem of how student work will get to the teacher, for a digital workflow system to truly support students with disabilities, the digital file exchange must work both ways: That is, there must also be a way for *teachers* to get documents—such as quizzes, tests, and worksheets—*to* their students. Orth (2013) provides practical advice on setting up a digital workflow system in schools.

Writing Tools at the Emergent Literacy Level

Students with disabilities who have not yet developed literacy skills, such as young children and children with cognitive or multiple disabilities, can experience success in early writing when provided with appropriate technology tools. Until recently students with severe disabilities were

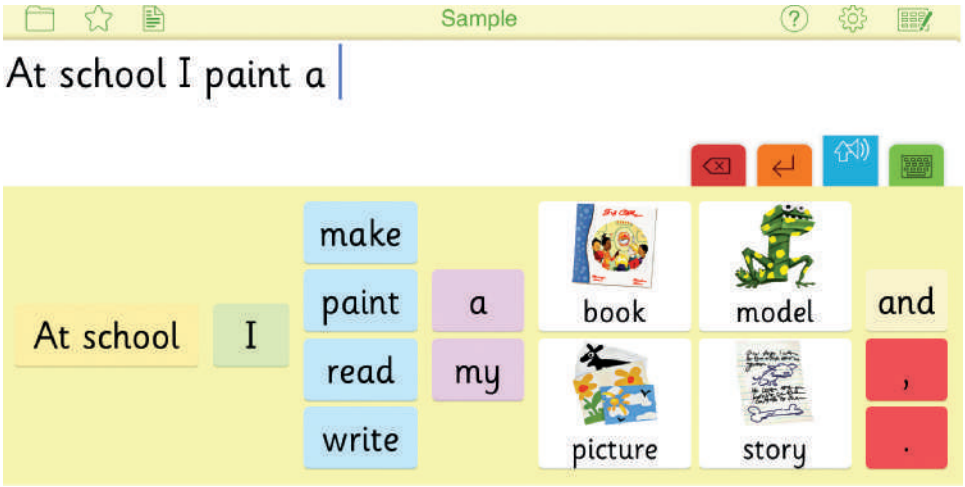
Learn more about word processing with text-to-speech capabilities by viewing demonstrations of two products:

- Crick's Clicker Docs: https://youtu.be/KmTU1FPHtBI
- WriteOnline: https://youtu.be/wLjB1AQuPTo

Mobile Devices as Writing Tools

Many apps are available for iPads and Android devices that combine word processing, text-to-speech, and word prediction capabilities. Apps such as ClaroSpeak, Co: Writer, Voice Dream Writer, Write Online, iWordQ, and iRead Write are easy to use and can provide valuable support to struggling writers. However, for mobile devices to be truly effective writing tools, two accessories are essential: (1) an external, wireless keyboard and (2) a stand or case that positions the mobile device and keyboard appropriately. Wireless keyboards equipped with Bluetooth technology initially need to be paired with the mobile device, but after the initial setup, the device will recognize the keyboard when it is turned on. Some teachers like to mount the iPad on a stand (many different styles are available) so it is positioned at a comfortable angle and easily seen by the student. Others prefer the setup of a case that holds both the device and the keyboard that can be maneuvered in such a way that the iPad stands at an angle behind the keyboard.

FIGURE 2.6 Clicker Connect (Crick Software) offers word grids, text-to-speech, and a simple interface to support the writing of young children and children with severe disabilities.



Source: Reproduced with permission of Crick Software, www.cricksoft.com.

not *expected* to develop literacy, and the focus of teaching was on recognizing sight words only (Carnahan, Williamson, Hollingshead, & Israel, 2012; Prest, Mirenda, & Mercier, 2010). That limited approach has been challenged by the recognition that students with Down syndrome and other cognitive disabilities *can* develop more advanced literacy skills *if* they are provided with appropriate literacy experiences and instruction. Trenholm and Mirenda (2006) surveyed parents of adult children with Down syndrome and found that 47 percent reported that their adult children were able to read at a grade 3–4 level; 25 percent reported even higher reading levels.

In addition to their cognitive disabilities, children with Down syndrome often have low muscle tone and poor motor control, both of which make handwriting—and even typing—difficult. Along with text-to-speech, an adaptation that has been shown to be a helpful writing support with this population is symbol-supported writing software. These software programs and iPad apps pair picture symbols with words.

Clicker 6 and a series of three Clicker apps from Crick Software (Clicker Sentences, Clicker Connect, and Clicker Docs) are good examples of this type of technology. They provide a simple interface with a child-friendly font; text-to-speech to read aloud both prompts and students' writings; a picture library to help students find and read the right words; and teacher-created word grids that provide point-and-click access to whole words, phrases, and pictures (see Figure 2.6). When Prest et al. (2010) studied the effect of using an earlier version of Clicker on the writing output of children with Down syndrome over a two-year period, they found that the quality of the students' writing improved in the first year, and their rate of writing (words per minute) improved in the second year.

Two important findings of the Prest et al. (2010) study are that students were not given sufficient time or support on the computers to develop their writing skills, and teachers and other school personnel did not have adequate time or training to develop the kinds of individualized grids and word bars that are needed for Clicker to be used to its maximum benefit. According to these researchers, "Students are unlikely to benefit from use of the software without ongoing support"; the most significant barriers to implementing Clicker successfully are finding sufficient teacher time and providing sufficient teacher training to maximize the tools' potential.

Hanser (2009) and her colleagues at the Center for Literacy and Disability Studies recommend the use of "alternative pencils" to facilitate emergent writing in students with severe physical and multiple disabilities. Alternative pencils include low-tech items such as eye gaze frames and print flip charts, as well as high-tech products such as apps like Clicker Sentences and Clicker Connect, Intellikeys overlays (see Chapter 9), and BoardMaker (see Chapter 10).

Watch students with intellectual disabilities learn to write using the story-writing app, Pictello: https://youtu.be/3dhVekGIRVY

See demonstrations of two apps from Crick:

- Clicker Connect: https://youtu.be/vGixr2ONub0
- Clicker Sentences: https://youtu.be/Rznn9i-3mUc

WORD PREDICTION APPS: The drafting (composing) process can also be supported through judicious use of **word prediction apps**. Word prediction apps, such as Co: Writer (Don Johnston),

FIGURE 2.7 Sample screen in Co:Writer, a word prediction program, with the topic dictionary "dinosaurs" selected.

Source: Image provided courtesy of Don Johnston Incorporated.

Word Q (goQ Software), Claro Speak, WriteOnline (Crick Software), and Voice Dream Writer, make an educated guess about the next word a student wants to type and present a list of choices (see Figure 2.7). The student glances over the list of choices and, if his or her word appears in the list, selects it simply by clicking on it or typing the corresponding number. The word then appears in the sentence followed by an appropriate space.

See how word prediction helps a boy with learning disabilities in *Action Video Series: Meet Brody!*:

https://youtu.be/D6i5CtPoGh0

Cell phone users are familiar with a version of word prediction called "auto-complete," "auto-correct," or "word completion." Although the concept is similar, word prediction apps that are designed for people with disabilities provide several additional features to support struggling writers. The word choices presented are based on context, meaning, and the rules of grammar, not simply typical typing mistakes. Several choices are offered, and they can be read aloud with text-to-speech to help the writer determine which word is the correct option.

Because the use of word prediction technology reduces the number of keystrokes needed to express a thought, it has been widely used by individuals with physical disabilities. It is especially helpful for students who type with a single finger (or a dowel, like Bob Williams) or those who use an alternative access method (see Chapter 9) and whose typing speed is extremely slow. It also serves as a helpful writing tool for students with learning disabilities who have severe spelling problems (MacArthur, 2013).

Good word prediction apps present their choices based on the initial letter that is typed by the user and the rules of grammar. For example, if a student types "Yesterday we …," a grammatically sensitive word prediction app will guess that the next word will be a verb and will present mostly verbs in its initial list of guesses. These programs can also be set to "favor" previously used words: The program "remembers" the words a user typed earlier and presents these words first in the lists of guesses. For example, if the user's name is Juanita, anytime she types a Shift-J and the program infers a noun may be needed, "Juanita" will appear as one of the choices in the list.

A feature of word prediction apps that is especially helpful for struggling writers is the ability to customize the dictionary and set up **custom dictionaries**. Custom dictionaries include vocabulary that is specific to a particular writing activity or subject. Often they include technical terms that are not included in a program's standard dictionary. For example, if a student is writing a paper on dinosaurs, a custom dictionary can be set up that includes *Triassic*, *Jurassic*, *Early Cretaceous*, *Late Cretaceous*, *Allosaurus*, *Plateosaurus*, *Coelophysis*, *Erythrosuchus*,

Scutellosaurus, *Heterodontosaurus*, *Megalosaurus*, and other technical terms that are not found in a typical spell-check dictionary. When a student types the letter A, for example, *Allosaurus* is likely to be one of the choices. (See Figure 2.7.)

Custom dictionaries can be extremely helpful for students with learning disabilities who have severe spelling problems. With these students, the spelling is so out of the ordinary that standard spell-checks are not effective because they cannot guess the intended word. Such students are likely to find word prediction apps that use **phonetic dictionaries** more helpful. Phonetic dictionaries are programmed to identify misspelled words by the way they sound, not just by the way they look. For example, if a student tries to sound out the word *physical* and begins typing "fzic" in Co: Writer, the list of predicted words will include "physical." Or if a student tries to sound out the word *photosynthesis* by typing "fotos," the program will provide the following choices: photos, photosensitive, photostatic, photosynthesis.

An additional feature that helps poor spellers is that when the mouse is moved over a choice in the predicted words list, the program speaks aloud the word. Similarly, on mobile devices, swiping a choice in the word list will enable to user to hear the word pronounced. Students who cannot visually recognize the correct spelling of a word can often make their selection based on the way the word sounds.

- How does word prediction work? TextHelp shows it in action in Read &Write: https://youtu.be/5Mp_10tPcCU
- Discover its features: https://youtu.be/EDDRPqleU2M
- Take a tour of Don Johnston's Co: Writer: https://youtu.be/4G9nhvA67YM

Integrated Writing Apps

Since the advent of iPads and other mobile devices, several apps have been developed that offer word processing capabilities combined with text-to-speech and word prediction. WriteOnline (Crick Software), ClaroSpeak, and Voice Dream Writer are examples. Their text-to-speech feature enables students who have weak reading skills to review what they have written and find and correct their writing errors. Their word prediction feature provides spelling and grammar support. Write Online also offers "wordbars," which are on-screen word banks that offer point-and-click access to words and phrases for specific curriculum-related writing tasks. These are easily constructed by teachers and/or downloaded from the publisher's teacher resource website (http://www.learninggrids.com).

Research on the use of word prediction and text-to-speech by students with learning disabilities, although not extensive, demonstrates that these tools can have a positive impact on developing writers (Silió & Barbetta, 2010). In Silió and Barbetta's study, fifth graders "wrote longer, more syntactically mature compositions that were better organized and had fewer spelling errors" (p. 25) during the experimental condition. Cullen, Richards, and Frank (2008) found that use of such tools by fifth graders was associated with a decrease in misspellings, an increase in accuracy and number of words, and overall improvements in the district's writing rubric scores.

Other research on word prediction provides helpful direction regarding its use. The size of the vocabulary available in the dictionary or custom dictionary, as well as the content, must be tailored to the specific writing task (MacArthur et al., 2001). Early writers perform better when the dictionary selected is a small one and includes a focused set of words. Students writing a research paper on a particular topic will perform better if a larger dictionary is selected and relevant proper names and technical vocabulary are added to the dictionary.

When the match between a writing task and the predicted words is a good one, students can easily find the words they are attempting to spell. Conversely, if the match is a poor one, students can quickly become overwhelmed by lists of irrelevant choices and will not find word prediction to be a helpful tool.

AUTOCORRECT: For students who enter text very slowly because they have physical disabilities, a feature called AutoCorrect can be used to speed up the drafting process. AutoCorrect allows users to create typing shortcuts. When users type abbreviations or press function keys to which they have assigned a special meaning, AutoCorrect enters an entire phrase automatically. For example, in typing this chapter, we entered "AT" for the phrase "assistive technology." Every time "AT" was typed, the entire phrase "assistive technology" was automatically entered in the document. This feature is especially useful for students' names and specialized vocabulary words that are needed for a writing assignment.

USER PROFILE

Josh

Josh is an eighth-grade student who enjoys many of the pastimes that other 14-year-olds do. He listens to music and talks to girls on the phone. He likes to play baseball, soccer, and roller hockey, and he attends sleep-away camp in the summer. At a young age, Josh was found to have severe learning disabilities that resulted in significant academic deficits, specifically in written language. Josh's learning disabilities are evident in any subject that requires organization, handwriting, spelling, or composition.

In the short amount of time that I spent with Josh and his parents, I was able to catch a glimpse of the intense frustrations that they have all experienced as a result of these deficits. Josh's parents handed me a stack of letters that Josh had written the previous summer from sleep-away camp. I glanced through the crumpled pages trying to make out a word here or there. In most of the letters, I was able to decipher only the date, the greeting "Mom & Dad," and the closing "Love, Josh." The illegible words were not even written on any lines. They zigzagged up and down the page, looking as if they were not organized in any logical fashion. His parents described to me how they would sit together and try to read the letters. Usually, they could not decipher more than a sentence or two. They explained the frustration of not knowing what their son was trying to tell them.

Josh's parents pointed out that even if you can get used to his handwriting, the next obstacles are spelling and composition. Josh has difficulty understanding the connection between sounds and letters. This, in turn, creates big problems with spelling. His phonemic unawareness was evident as I tried to read through the camp letters.

When Josh was in seventh grade, his parents were referred to an Alliance for Technology Access (ATA) center in their state. The assistive technology specialist at the center tried several different software programs to help Josh with his writing. When she introduced him to word prediction, Josh typed a complete sentence and then turned to his mother and asked, "Can I write some more?" Josh's mother was overcome—this was the first time she had ever seen her son show any competence or interest in writing.

Josh uses word prediction to complete his writing assignments in school and homework assignments. For example, he now does his weekly vocabulary assignments on the computer. For these assignments, he has to write original sentences using his vocabulary words. In the past, Josh would either write out the sentences, which usually meant that they were illegible, or he would dictate the sentences to his mother and she would type them on a word processor. Now, Josh is able to complete these types of assignments on his own. This is important progress for an adolescent in middle school. His parents are very pleased with the way his writing has progressed.

Source: Niemann, D. (1996). Word prediction makes the difference: Learning disabilities in middle school. *TECH-NJ*, *8*(1), 4. *http://www.tcnj.edu/~technj/fall96/writeaway.html*. Editor-in-Chief Professor Amy G. Dell. Used by permission.

In word processing apps such as Microsoft Word, AutoCorrect is found under the Tools menu. On mobile devices such as iPads, it is found under Settings → General → Keyboard → Add New Shortcut.

SPEECH RECOGNITION APPS: Also known as "dictation apps," speech recognition apps have received a lot of attention in the mass media and, in turn, a lot of interest from parents. Why, then, do we leave them for last in our discussion of the drafting phase of writing? Speech recognition applications such as Dragon NaturallySpeaking (Nuance) enable a user to dictate his or her words into a computer that is equipped with a microphone. This technology bypasses the keyboard completely. However, although it holds promise for students who struggle with handwriting and keyboards, it continues to have a number of limitations that make it a useful writing tool for only a small number of students with disabilities.

Although the accuracy rates of speech recognition apps are said to be in the vicinity of 95 percent when used by trained users, the accuracy rate with children—and in particular with children with disabilities—is unknown and is likely to be considerably lower (MacArthur, 2009). That is because *any* percentage of inaccuracies poses problems for the writing process for students with disabilities. Consider that speech recognition requires students to do the following tasks, sometimes simultaneously:

- Think about what they are going to say
- Speak the thought aloud
- Speak any punctuation and capitalization

- Read on the monitor what the program understood them to say
- Decide if that was actually what was said (recognize mistakes)
- Correct the program if it misunderstood
- Go back to picking up the train of thought

Because of this rather complicated set of steps, instead of making writing simpler, speech recognition adds a substantial cognitive burden to the writing process. It is not likely to facilitate the composition process for students who are weak in reading or have difficulty multitasking.

Another limitation of speech recognition is the environment of typical schools:

> Despite its potential, speech recognition raises many practical issues. It is difficult to use speech recognition in a school environment because the software requires a reasonably quiet environment for accurate recognition. Also, it makes composing a more public effort, which may be embarrassing, especially for struggling writers … In addition, students must make a commitment to learning to use the software effectively. (MacArthur, 2009, p. 252)

What does MacArthur mean by "a commitment to learning to use the software"? Many hours of time need to be devoted to training the app to recognize a student's voice and training the student to use the sophisticated technology. In one study, students received six hours of training to use speech recognition software (MacArthur & Cavalier, 2004). Cavanaugh (2008/2009) presents a helpful framework for structuring this kind of extensive training, but not many schools have the resources to provide such elaborate grounding in the technology.

USER PROFILE

Megan M.

Megan M., a 23-year-old college graduate, uses Dragon Naturally Speaking Professional (Nuance), a voice recognition program, to write on her computer. By dictating her words into a microphone, she is able to control both the mouse and the keyboard solely with her voice. Megan needed to explore different access methods because she has very limited use of her arms due to a form of muscular dystrophy called Werdnig-Hoffmann's disease type II.

Before she learned how to use Dragon, Megan's computer access was very limited, and she was dependent on other people to write for her. Typing "just became too troublesome and time-consuming, so I would end up dictating in the end. Dictation was my method of 'typing' for years." Megan typically relied on "my student aides or brother or sister, or whoever was around, to do the physical typing while I dictated. It was extremely time-consuming, not only for me, but for the people helping me as well."

At age 18, Megan worked with an assistive technology specialist to find a better solution for her computer access. "The technician evaluating me thought I would be a great candidate for using Dragon because I had fine speech and the cognitive ability to handle the training." Megan began using the program at college where she received technical support from the director of the disability support office. She started with a tutorial, but it was through use over time, and much trial-and-error, that Megan fully grasped the program's capabilities.

"As time went on and I began mastering Dragon, I began doing my own work completely independently. I started out with small papers and assignments, then I started surfing the Internet for research and whatnot, and before I knew it, I was doing a 22-page senior seminar paper, research and all."

Megan emphasizes that this efficiency did not occur overnight. It took her three to five months to feel comfortable with the program, and it was not until a year of use that she felt she had truly mastered the software:

> Learning this program is very much like learning another language. At first I was very slow, saying only short sentences and making sure the process was actually working. It's a very strange feeling talking to a computer and seeing visual results in front of you immediately. As time went on and I had a better understanding of how the program worked and how I could work with the program, my speed and accuracy became faster and greater. The language of Dragon has become second nature to me. Now I can talk for sentences without worrying about how the program is responding. If a problem arises, I know I can fix it.

Source: Adapted from Schindler C. (2005). Voice recognition provides independence for Ramapo College student. *TECH-NJ*, *16*(1). Retrieved February 10, 2015, from http://www.tcnj.edu/~technj/2005/ramapo.htm. Editor-in-Chief Professor Amy G. Dell. Used by permission.

Nevertheless, for a small number of older students with disabilities who meet the following criteria, speech recognition has been shown to be an effective writing tool: (1) The students are computer savvy and enjoy solving technical problems; (2) the students have strong oral language skills and understand the differences between spoken and written language; (3) the students and their teachers and parents receive extensive training on how to use speech recognition; and (4) the students are highly motivated to make it work and are willing to persevere (National Center to Improve Practice, 1999).

Reviewing and Editing

The reviewing part of the writing process, which is so difficult for students who have poor reading skills, is made easier by the use of **text-to-speech**. The more sophisticated text-to-speech apps also offer a **highlighting** feature that helps students read and evaluate what they have written. Students can choose to have their writing highlighted word by word, phrase by phrase, sentence by sentence, or paragraph by paragraph. A common choice is to have the chunk of text being read aloud (such as a sentence) highlighted in one color, while having a second color highlight what is being spoken word by word. This arrangement supports students with reading difficulties by helping keep their eyes on the chunk of text they are trying to evaluate and revise.

We have already mentioned that the ability to manipulate text afforded by word processing applications "makes revision possible without tedious recopying" (MacArthur et al., 2001, p. 288). Research supports the idea that allowing students who have learning disabilities to write with word processing applications, in combination with instruction on revising strategies, improves the overall quality of their writing (MacArthur, 2009). In addition to this editing power of word processing, the revising process can be significantly enhanced through the use of several other technology tools, some that we have already described. In the following subsections, we will discuss spell-checks, thesauruses, grammar checkers, homonym finders, text correction software, and Track Changes and Insert Comments features.


Informative videos and learning guides on all of these writing tools are available on the website of the Edmonton, Alberta Regional Learning Consortium:

https://www.learningtechnologiesab.com/

SPELL-CHECKS: Built into word processing apps and many Internet browsers, spell-checks quickly find words that have been misspelled. If the writer chooses, spell-checks can also guess which word the writer intended and then present a list of possibilities, in which each guess is spelled correctly. This feature is an extremely helpful tool for skilled readers and writers because it picks up typographical errors as well as true spelling errors, and these users can quickly correct their mistakes by choosing the right word from the word list.

For many students with learning disabilities, however, standard spell-checks present a new set of problems. In fact, for students who are poor readers, the list of suggested words can add to their confusion. For example, a student who types "redy" for "ready" may be presented with seven possible words (reedy, red, rudy, rey, rely, redo, reds) before "ready" is suggested. Many of these words look similar, and the poor reader or speller may not be able to distinguish the correct word from the list of choices. In addition, for students who have severe spelling problems, conventional spell-checks often do not guess correctly; as a result, the list of choices presented may not include the student's intended word. For example, if a writer spells the word *reference* as "refrins," the spell-check in Microsoft Word presents three choices: refrains, refries, refines. This list of choices will not help the writer who needed to spell *reference*.

Poor spellers may benefit more from spell-checks that use text-to-speech to read aloud the choices presented. Students who are poor readers can listen to the words and choose the correct word based on how it sounds. If the student is still uncertain of the correct word, talking spell-checks read aloud the words' definitions, and the student can make a choice based on the correct definition.

THESAURUSES: Many skilled writers use a **thesaurus** to help them with their word choices. This kind of electronic tool can also help improve the writing of students with learning disabilities. Sometimes called a "synonym finder," thesauruses present a list of words with similar meanings to the selected word. If users find the choices in Microsoft Word's thesaurus too limiting, they can go to a web-based thesaurus that offers more comprehensive lists of choices—for example, http://www.thesaurus.com, http://www.dictionary.com, or http://www.visualthesaurus.com.