Technology is now a part of the lives of all students inside and outside of school. In fact, recent statistics suggest students are increasingly spending their time outside of school with technology, resulting in some calling today’s students the iGeneration (Coldewey, 2010; Rosen, 2011). To illustrate the trend in technology use, surveys suggest the majority of school-aged children own cell phones—increasingly smartphones (Madden, Lenhart, Duggan, Cortesi, & Gasser, 2013; Rideout, Foehr, & Roberts, 2010). The majority of U.S. teenagers also report access to a computer at home (Herrick, Fakhouri, Carlson, & Fulton, 2014; Madden et al., 2013).

Educational technology is defined multiple ways, including the study and practice of facilitating learning and improving performance by creating, using, and managing technological processes and resources (Mishra, Koehler, & Kereluik, 2009). In other words, educational technologies are tools that address educational problems, for instance, issues of teaching and learning (Newby, Stepich, Lehman, & Russell; 2000). While some narrowly define educational technology as computers and computer-based applications, many define it in a broader sense and suggest educational technology has existed since the era of chalk and slate (Blackhurst, 2005a; Mishra & Koehler, 2009). Regardless of the concept of educational technology, one thing is consistent—the claim that use of a particular technology in education will revolutionize teaching and learning. Such claims were made for the talking picture (Devereux, 1933; Mishra et al., 2009), the blackboard (Lewis, 1988), and cell phones (Kolb, 2008; Mishra et al., 2009), just to name a few.

Despite the term educational technology, Mishra and Koehler (2009) suggest the technologies teachers typically use in education are not designed for educational purposes; rather, teachers repurpose such technology to be educational. In other words, teachers often take a technology, regardless of its intended purpose, and use it to fit their needs in the classroom (Kereluik, Mishra, & Koehler, 2011; Mishra & Koehler, 2007). Repurposing can involve such common technologies as digital cameras and software (for example, Photoshop) for taking pictures of objects and then manipulating the images to demonstrate mathematical concepts such as transformations (Terry, Mishra, Henriksen, Wolf, & Kereluik, 2013), as well as social media like Facebook (Kereluik, Mishra, & Koehler, 2010).
Within educational technology, pulling from a wide conceptualization, Blackhurst (2005a, 2005b) suggests the existence of six distinct types: technology of teaching, medical technology, productivity technology, information technology, instructional technology, and assistive technology (see Table 5.1). Technology of teaching is typically devoid of tools or devices, as it refers to instructional techniques. Medical technology involves devices used to support and monitor a medical condition or one’s health. Tools that help educators and students create products efficiently and effectively are considered productivity technologies. Information technologies involve tools that provide resources and access to information. Instructional technology involves hardware and software designed to support effective instruction to increase student learning. Finally, assistive technologies are tools and devices that support students with disabilities to access materials, increase independence, and experience an improved quality of life (Blackhurst, 2005b).

**Assistive Technology**

Assistive technology actually refers to devices and services, although most commonly people associate the term *assistive technology* with the tools or devices. An *assistive technology device* refers to “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 the functional capabilities of a child with a disability” (Individuals with Disabilities Education Improvement Act of 2004, Section 300.5). *Assistive technology services*, as defined in Public Law (PL) 100-407, include “any service that directly assists an individual in the selection, acquisition, or use of an assistive technology device.” While devices are the tools and technologies that students use, assistive technology services are a necessary component and involve selecting (based on an evaluation of a student’s assistive technology needs), acquiring, implementing, and maintaining devices (Parette, Peterson-Karlan, & Wojcik, 2005). Assistive technology services can be provided by an *assistive technology specialist*; however, these individuals may be infrequent within a school system. In that case, special education teachers, speech-language pathologists, occupational therapists, and/or instructional technologists may be responsible for providing assistive technology services (Edyburn, 2004; Marino, Marino, & Shaw, 2006). See Figure 5.1 for a diagram of assistive technology services.
History and Legislation of Assistive Technology

The previous definitions of assistive technology devices and services are found in IDEA 2004 (the Individuals with Disabilities Education Improvement Act) and PL 100–407, the 1988 Technology-Related Assistance for Individuals with Disabilities Act (also known as the “Tech Act”). The Tech Act was reauthorized in 1998 and again in 2004 as the Assistive Technology Act. However, actual use and legislation pertaining to the idea of assistive technology far predate the 1988 Tech Act. For example, in 1832, Louis Braille published the Braille code (Blackhurst, 2005a). Since then, we have seen the invention of electric amplifying devices for individuals with hearing impairments (1900), devices to magnify printed material (1953), and the talking calculator (1975), to name just a few (Blackhurst, 2005a; Nazzaro, 1977). In the 1970s, with the invention of the microcomputer, additional assistive technology became available to support students with disabilities, including text-to-speech (voice output of digital words so students can hear the text), augmentative and alternative communication (AAC) devices (low-tech, mid-tech, and high-tech communication tools that can replace, supplement, or enhance one’s traditional means of communication), and speech-to-text (spoken words appearing as typed text on a computer-based technology) (Belson, 2003; Blackhurst, 2005a).

Legislation for assistive technology also predates the 1988 Tech Act. In 1879, following the invention of Braille, PL 45–186 was passed, which authorized funding for the production of Braille materials by the American Printing House for the Blind. In 1958, PL 85–905 provided funding to purchase and distribute closed-captioned films to state schools for the deaf. The Elementary and Secondary Education Amendments of 1968, PL 90–247, legislated the provision of educational technology for students with disabilities (Blackhurst, 2005a).
However, much of what guides assistive technology today for students with disabilities comes from reauthorizations of the Individuals with Disabilities Education Act (IDEA). Although IDEA was initially passed in 1975 (PL 94–142), it was not until the 1990 reauthorization (PL 101–476) that assistive technology was included. The 1990 authorization of IDEA included the Tech Act definition of assistive technology as well as provided for assistive technology if the individualized education program (IEP) team determined it was needed (Smith & Jones, 1999). The 1997 reauthorization of IDEA mandated that IEP teams consider assistive technology for all students with disabilities, shifting the focus of assistive technology as primarily for students with more severe or low-incidence disabilities (for example, students with visual impairments or students with severe intellectual disability) to also include students with high-incidence disabilities, such as individuals with learning disabilities (Quinn et al., 2009; Smith & Jones, 1999).

The latest reauthorization of IDEA in 2004 upheld the mandate that IEP teams consider assistive technology for all students with disabilities and that, pending determination by the IEP team, the assistive technology be provided at no cost to the student (Lee & Templeton, 2008). However, there was one exclusion in IDEA 2004; surgically implanted assistive technologies (for example, cochlear implants) were omitted from the definition of assistive technology. Consequently, schools are not required to pay for such devices (Zirkel, 2007). Related to assistive technology, IDEA 2004 included the National Instructional Materials Accessibility Standard (NIMAS), which stipulated students with print disabilities, commonly considered students with visual impairments and reading-based learning disabilities and sometimes particular physical disabilities, be provided with accessible instructional materials, such as large print, Braille, or digital text (National Center on Accessible Instructional Materials, 2011).

**Assistive Technology Decision Making**

As previously stated, assistive technology services provide for the consideration, selection, acquisition, and implementation of assistive technology devices and tools for students with disabilities. But how do IEP teams consider and select assistive technology for an individual student? While making an assistive technology decision can be challenging, given the range and types of tools and devices available, frameworks do exist to aid IEP teams in their decision-making progress. Perhaps the most well-known decision-making framework is the Student, Environments, Tasks, and Tools (SETT) framework by Joy Zabala (1995). (See Table 5.2 for assistive technology decision-making resources.) The SETT framework involves the identification and consideration of the student (for example, strengths, needs, and preferences), the environments in which the student functions, and the tasks the student is expected to perform. In other words, the tools selected need to match with the pupil, work within various environments, and adequately and appropriately address the student's tasks. The SETT framework is similar to the Matching Person and Technology (MPT) framework, which also suggests assistive technology devices or tools should match...
Beyond the SETT and MPT, other grant-funded projects and initiatives created decision-making tool kits for IEP teams to use in considering and selecting assistive technology for individual students. For example, the Wisconsin Assistive Technology Initiative (WATI) created an assessment system to help IEP teams identify the types of technology that may benefit students with various disabilities, based on the students’ abilities and challenges, environments, and tasks (Gierach, 2009). Lahm et al. (2002) developed the University of Kentucky Assistive Technology (UKAT) Toolkit, which provides resources in the form of worksheet-like pages to complete in order to guide an IEP team through assistive technology decision making. Lastly, the National Assistive Technology Research Institute (NATRI) developed an assistive technology planner for use by teachers, parents, and students to actively participate in assistive technology planning and decision making on an IEP team (Bausch & Ault, 2008; Bausch, Ault, & Hasselbring, 2006).

When IEP teams are making assistive technology decisions, they may opt for a student to try out an assistive technology device or tool before recommending that the pupil use such assistive technology. IEP teams can take advantage of state lending libraries. For example, in the state of Indiana, the Promoting Achievement through Technology and Instruction for all Students (PATINS) Project (www.patinsproject.com) serves as the statewide technical assistance network for assistive technology. PATINS not only lends assistive technology to schools to aid in decision making but also provides educators in the state with professional development related to assistive technology through face-to-face conferences as well as online tutorials or webinars. We recommend that IEP teams consult their state assistive technology project for resources as well as devices and tools available through their lending libraries. (See Table 5.3 for examples of state programs.)

### Assistive Technology and the IEP

As previously noted, IEP teams (and individualized family service plan teams for youngsters from birth to age 3) are required to consider assistive technology for all students with disabilities. Assistive technology is included within a student’s IEP as appropriate. It can be represented in multiple ways—for instance, as a related service, as an accommodation, or as an annual goal or short-term objective, where appropriate.
Typically, however, assistive technology is selected and implemented to assist a student in meeting his or her goals. Hence, IEP teams may want to consider assistive technology toward the end of an IEP meeting (Beard, Carpenter, & Johnston, 2011). It is important for IEP teams to remember that if assistive technology devices or services are written into a student’s IEP, it is the responsibility of the school to cover the costs. However, schools are not required to pay for all assistive technology (for example, surgically implanted assistive technology); hence, other outlets, such as private insurance, Medicare, Medicaid, or donations, are frequently used by families.

### Assistive Technology Categorization

Assistive technology, by its definition in IDEA 2004, is vague and ambiguous. Broken down, assistive technology essentially is anything or can come from anywhere, as long as it helps or just maintains an individual’s skills. Because assistive technology can be anything, it can be instructional technology (something that teachers use in the instruction of all students; for example, computer-based concept mapping and calculators), it can be everyday technology that is repurposed (for example, cell phones and iPads), and it can be specifically designed tools and devices (such as text-to-speech, speech-to-text, and AAC) (Bouck, Flanagan, Miller, & Bassette, 2012; Bouck, Shurr et al., 2012; Edyburn, 2004). In other words, the definition of assistive technology can leave one with two questions: “What isn’t assistive technology?” and “When is something assistive technology?” (Edyburn, 2004).

Given the questions surrounding what is and what is not assistive technology, a way to better understand assistive technology is through the different categorization schemes. One way in which assistive technology is often categorized is through the level of technology. While typically one conceptualizes assistive technology as low-tech (minimum technology) or high-tech (sophisticated technology), other conceptualizations also exist, including no-tech, low-tech, mid-tech, or high-tech as well as low-tech, moderate-tech (or mid-tech), or high-tech (Blackhurst, 1997; Edyburn, 2005; Johnson, Beard, & Carpenter, 2007; Vanderheiden, 1984). No-tech assistive technology most commonly refers to when no tool or device is actually used, but perhaps a teaching strategy is implemented, such as a mnemonic (Behrmann & Jerome, 2002; Blackhurst,
1997). Low-tech assistive technologies are generally tools or devices that are low in cost, require less training, and are typically not sophisticated (for example, pencil grips) (Behrmann & Schaff, 2001; Blackhurst, 1997). Moderate- or mid-tech assistive technologies are then typically tools or devices that are battery operated; the technology is more sophisticated, may require more training, and has a higher cost than low-tech assistive technology (for example, a calculator). Finally, high-tech assistive technologies are sophisticated devices and tools and are commonly associated with computer-based technology. High-tech assistive technologies are considered to have a higher cost and require more training (for example, text-to-speech) (Blackhurst, 1997; Edyburn, 2005; Johnson et al., 2007; Vanderheiden, 1984). See Table 5.4 for examples of assistive technology devices according to categorization.

Another way assistive technology can be categorized is by purpose. Bryant and Bryant (2003) suggested seven purposes for assistive technology: positioning, mobility, augmentative and alternative communication, computer access, adaptive toys and games, adaptive environments, and instructional aids. Likewise, the WATI suggested fourteen categories for assistive technology: seating, positioning and mobility, communication, computer access, recreation and leisure, activities of daily living, motor aspects of writing, composition of written material, reading, mathematics, organization, vision, hearing, and multiple challenges (Gierach, 2009). See Table 5.5 for examples of assistive technology devices by purpose. Overall, these categorizations suggest assistive technology can meet a wide range of needs for a diverse population of students with disabilities.

### Devices and Tools

Assistive technology is central to the education of students with disabilities. Each chapter in Part 2 of this book examines assistive technology tools and devices that are unique or commonly used by individuals with a specific disability such as an AAC device for pupils with speech and language impairments or various sound amplification systems for students with hearing impairments. We now focus our attention on assistive technology within content-specific domains, as well as other organizational capabilities for students with high- and low-incidence disabilities. In addition, we touch upon assistive technology for young children with disabilities and the association between universal design for learning and assistive technology.

### Reading

Reading is a fundamental but complex skill and often considered the most critical academic skill (Strangman & Dalton, 2005). In 2000, the National Reading Panel suggested reading instruction should consist of five areas: phonemic awareness, phonics instruction, fluency, vocabulary, and reading comprehension. Despite its value, reading is an area of struggle for many students, with varying statistics presenting the frequency of struggling readers, let alone students with disabilities. The most recently available

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**TABLE 5.4 Examples of Assistive Technology Devices by Categorization**

<table>
<thead>
<tr>
<th>No-Tech</th>
<th>Low-Tech</th>
<th>Mid-Tech</th>
<th>High-Tech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mnemonics (HOMES for remembering the names of the Great Lakes)</td>
<td>Pencil grips</td>
<td>Calculators</td>
<td>Speech-to-text</td>
</tr>
<tr>
<td>Graphic organizers</td>
<td>Raised lined paper</td>
<td>Audio recorders</td>
<td>iPad</td>
</tr>
<tr>
<td></td>
<td>Highlighter strips</td>
<td>Switches</td>
<td>Word prediction</td>
</tr>
<tr>
<td></td>
<td>Braille playing cards</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### TABLE 5.5 Example Assistive Technology Devices by Purpose

|--------------------------------|------------------------------------------------------------|----------|
| Seating, positioning, and mobility | Positioning | • Adjustable-height desks  
| | Mobility  
| | Seating | • Custom wedges  
| | | • Wheelchair  
| | | • Gait trainer |
| Augmentative and alternative communication | Communication | • Picture Exchange Communication System®  
| | | • Proloquo2Go® for iPod, iPad |
| Computer access | Computer access | • Alternative keyboard  
| | | • Speech/voice recognition |
| Adaptive toys and games | Recreation and leisure | • Switch-operated battery toys  
| | | • Larger or Braille playing cards |
| Adaptive environments | Activities of daily living | • Adapted utensils, bowls, and cups  
| | | • Motion-controlled lights |
| Instructional aids | Motor aspects of writing | • Speech-to-text  
| | | • Pencil grips  
| | Composition of written material | • Word prediction  
| | | • Portable spell checker  
| | Reading | • ReadingPen  
| | | • E-text or supported e-text  
| | Mathematics | • Concrete or virtual manipulatives  
| | | • Calculator |
| | Organization | • WatchMinder  
| | | • Picture schedule |
| | Vision | • Text-to-speech  
| | | • Screen magnification |
| | Hearing | • FM system  
| | | • Hearing aid |


Data from the National Assessment of Educational Progress (NAEP), which assesses reading at Grades 4 and 8, suggest students with disabilities are faring poorer than their peers without disabilities. The average score in reading for fourth graders with disabilities was 187—below the basic level—and the average score for fourth graders without disabilities was 228, which is between basic and proficient. Similar results are found for eighth graders: The average score was 230 (below basic) for pupils with disabilities and 270 (between basic and proficient) for those without disabilities (National Center for Education Statistics, 2016). Given the challenges reading can pose, it is important to consider how technology can support these students. See Table 5.6 for examples of assistive technology used for instruction in the various content areas.
First Person: MATTHEW

Teaching in the Age of Technology

Since graduating with my bachelor’s degree in special education, I have worked at an alternative school. My school is a state-accredited residential and day school program that serves students between the ages of 6 and 21 who have learning disabilities and/or emotional behavior disorders and who struggle in a typical school setting, as well as students with intellectual disability and students with autism spectrum disorder. Our students with learning disabilities and/or emotional behavior disorders are not reading or writing at grade level. For our older students who still struggle with handwriting, pencil grips or weighted pencils are available. I do see pencil grips benefiting my students. For our younger students who struggle with reading, we take advantage of books on CD or electronic books played through an MP3 player. In my school, we have advanced technology to support students with more intense needs as well. Every classroom has an iPad, and we use Proloquo2Go® for students with communication needs. Most of our assistive technology needs and decisions for individual students are determined by our occupational therapists or speech–language pathologists.

—Matthew Wright
Program Coordinator
T. C. Harris School
Lafayette, Indiana

Low-Tech Reading Assistive Technology. When deciding on assistive technology, IEP teams should always first consider low-tech, of which there are a number of options for reading. There is not always a research base, however, on using the tools and devices for students with disabilities. Some common low-tech reading-based assistive technologies include highlighter pens, highlighter tape (nonpermanent), and highlighter strips—strips of colored, transparent film that students can use to guide their reading. Another low-tech means for providing support for reading is the placement of picture symbols in written text to provide additional support for comprehension (Shurr & Taber-Doughty, 2012).

Mid- and High-Tech Reading Assistive Technology. Many mid-tech and high-tech assistive technology devices and tools exist. Perhaps one of the most common technologies to consider for students who struggle with reading is text-to-speech. Text-to-speech, known by different names depending on its application (for example, screen readers when accessing text on a computer, or e-text) (Anderson-Inman & Horney, 2007), is essentially printed or digital text spoken aloud to the reader; in other words, there is a voice output. Not only did the National Reading Panel (2000) suggest text-to-speech as a promising intervention, but researchers found use of text-to-speech positively influenced decoding, fluency, and comprehension skills (Hasselbring & Bausch, 2005; King-Sears, Swanson, & Mainzer, 2011). However, it should be noted that the research is also full of contradictions regarding the positive or neutral effect of text-to-speech (Strangman & Dalton, 2005).

Many different types of text-to-speech options exist. For example, there is the ReadingPen 2, a handheld optical character recognition system that reads printed text as the device scans it (another example is Quicktionary2) (Schmitt, McCallum, Hennessey, Lovelace, & Hawkins, 2012; Schmitt, McCallum, Rubinic, & Hawkins, 2011; WizcomTech, 2013, 2014). A number of computer-based text-to-speech programs...
exist, including both free and for-purchase options. One free option, although one can also purchase its upgraded features, is NaturalReader (www.naturalreaders.com) (NaturalSoft Limited, 2015). NaturalReader is a downloadable option that provides natural-sounding voices and also highlights the text as it is read on Word documents, websites, PDFs, and e-mails on both PCs and Mac computers. Students can adjust the volume and pace of a voice even with the free version. Other free text-to-speech programs include browser-specific options, such as SpeakIt! for Google Chrome (Petrov, 2016). For-purchase text-to-speech programs also exist, such as Read&Write Gold. Not only does the program provide auditory text with simultaneous text highlighting on a computer, but the company also recently released an iPad version (Texthelp, 2015).

Closely related to text-to-speech is e-text or supported e-text. E-text is electronic text, and supported e-text is enhanced e-text, which includes such additional features to benefit students as linked dictionaries (Anderson-Inman & Horney, 2007). Use of e-text is related to the NIMAS, which mandated that students with print disabilities receive access to accessible text, including digital text (National Center on Accessible Instructional Materials, 2011). Several specifically designed e-text readers were developed following NIMAS, which supported a file format referred to as Digital Accessible Information System (DAISY) Digital Talking Books. ReadHear™, by gh, LLC, is one such technology. ReadHear™ offers many of the same features as text-to-speech programs, including synthesized speech and text highlighting. It also offers magnification and can be used through keyboard shortcuts for individuals with visual impairments. In addition, commercially available products, such as Kindle, Nook, and iPad, are becoming increasingly popular for providing e-text to students (Larson, 2010). However, not all e-readers meet the accessibility needs of all pupils, such as students with visual impairments. If a student does use an e-reader, he or she can acquire text from multiple places, including Amazon.com and other online sellers (for example, Barnes & Noble), as well as take advantage of free e-books, including those from iTunes, Bookshare (www.bookshare.org), and Project Gutenberg (www.gutenberg.org).

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**TABLE 5.6 Assistive Technology Examples for Content-Area Instruction**

<table>
<thead>
<tr>
<th>Low-Tech</th>
<th>Mid-Tech</th>
<th>High-Tech</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reading</strong></td>
<td><strong>Writing</strong></td>
<td><strong>Mathematics</strong></td>
</tr>
<tr>
<td>Highlighter strips or tape</td>
<td>Pencil grips</td>
<td>Concrete manipulatives</td>
</tr>
<tr>
<td>Picture symbols</td>
<td>Raised lined paper</td>
<td>Number lines</td>
</tr>
<tr>
<td>ReadingPen</td>
<td>Handheld spell checkers</td>
<td>Calculators (e.g., four-function, graphing)</td>
</tr>
<tr>
<td>Books on CD</td>
<td>Portable word processors</td>
<td>Virtual manipulatives</td>
</tr>
<tr>
<td><strong>Text-to-speech</strong></td>
<td><strong>Speech-to-text</strong></td>
<td><strong>Computer-assisted instruction</strong></td>
</tr>
<tr>
<td><strong>E-readers or supported e-text</strong></td>
<td><strong>Word prediction</strong></td>
<td></td>
</tr>
</tbody>
</table>

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**Video Case 5.1: Assistive Technology for Writing**

Name or describe three examples of low-tech assistive technology for writing and how these might benefit an individual with a disability.
Writing

Writing is another critical skill, but it often gets less attention than reading (National Commission on Writing for America’s Families, Schools, and Colleges, 2005). Writing is complex and multifaceted, involving not just technical elements like handwriting and spelling but also the processes of planning and organizing, generating and drafting text, and then editing and revising (Flower & Hayes, 1981). All of these components, from handwriting to planning to writing to revising, can cause challenges for students with disabilities (Mason, Harris, & Graham, 2011). Recent data from the NAEP writing assessment suggest students with and without disabilities struggle with writing (National Center for Education Statistics, 2012). The 2011 assessment found only 27 percent of eighth- and twelfth-grade students were above a basic level (that is, proficient or advanced), meaning almost three-fourths of students in each grade were at a basic or below-basic level. The data were not disaggregated for students with disabilities.

No- and Low-Tech Writing Assistive Technology. Many low-tech assistive technologies exist to support students with writing (see Table 5.4, page 141). For example, pencil grips and adaptive pens can help students with handwriting issues. Teachers can also use raised lined paper (a student can feel the lines of the paper), whiteboards, gel boards, and even shaving cream. Outside of the technical elements, no- and low-tech strategies can assist with the writing process. Advanced organizers such as procedural facilitators, graphic organizers, concept maps, and think sheets have a strong research base in terms of helping students with and without disabilities plan and organize their writing (Englert, Zhao, Dunsmore, Collings, & Wolbers, 2007). Whether using the advanced organizer–based acronym POWER—planning, organizing, writing, editing, and revising (Mariage, Englert, & Garmon, 2000)—or the hamburger paragraph organizer—in which the top bun serves as a topic or main sentence; the meat, lettuce, and tomato function as supporting sentences; and the bottom bun is a concluding sentence (Mariage & Bouck, 2004)—these tools help students to structure their writing for improvement in quality and quantity.

Mid- and High-Tech Writing Assistive Technology. A number of mid-tech and high-tech technologies exist to support the writing process as well as the technical components of handwriting and spelling. For the prewriting portion of the writing process, planning and organizing, students can use computer-based concept mapping programs, such as the for-purchase Inspiration and Kidspiration (Inspiration Software, 2012a, 2012b) or the free options CmapTools (Institute for Human & Machine Cognition, n.d.) and Visual Understanding Environment (Tufts University, 2008). Computer-based concept maps are similar to paper-based concept maps, although students can edit more easily with the computer options. In addition, some computer-based concept mapping programs come equipped with pictures to help students represent their ideas with images as well as words, and others include such built-in assistive technologies as text-to-speech and speech-to-text.

When writing or drafting, students can use a range of assistive technologies, including technology to actually get words on the paper as well as technology to select correct words. Speech-to-text—also known as speech or voice recognition—is
A computer-based program that translates the words a user says to typed text (Batorowicz, Missiuna, & Pollock, 2012; MacArthur, 2009). In other words, speech-to-text can create Word documents, e-mails, and other digital documents from narrated speech rather than keystrokes. Common speech-to-text programs are associated with a fee, such as Dragon NaturallySpeaking (Nuance Communications, 2015) for PCs or Macs. However, some free options exist, such as Dictation Pro (DeskShare, 2012) for Windows-based operating systems. Windows operating systems also come standard with Windows Speech Recognition, which can recognize voices and translate narration into text in different programs (Microsoft Windows, 2011). Likewise, Mac computers with the Mountain Lion and later operating systems also come standard with an easy-to-use speech-to-text program known as Dictation (Apple, 2015). Users should note that using speech-to-text programs may require training, and typically programs become better at recognizing one’s speech the more they are used.

Aside from speech-to-text, word prediction is another computer-based program that supports students in writing text. Word prediction programs predict what word an individual is typing, based on the letters, and provide suggestions (for example, as one types br-o, a word prediction program might suggest home, house, and hole) (MacArthur, 2009). A few free computer-based word prediction programs exist, such as eType (eType, 2012) and Turbo Type (Soft Grup Construct, 2015), which are both compatible with Windows-based operating systems. Both free options have drawbacks, including advertisements and needing to reboot after a length of time. For-purchase options include Co:Writer 7 (Don Johnston, n.d.), which is compatible with both PC and Mac computers; SoothSayer (Applied Human Factors, 2015), which is Windows based; and Typ-O (SecondGuess ApS, 2016), which works on Apple products including Mac computers as well as iPads and iPhones.

In terms of postwriting, students can use text-to-speech to receive auditory feedback on their writing as well as spelling and grammar check programs. The text-to-speech program NaturalReader can be used to support a student’s editing and revising through reading the text the student transcribed into the computer. Obviously, students can use the built-in spell-check programs with their word processing software, such as Microsoft Word. However, other free or for-purchase programs may provide additional support. For example, Ginger Software (n.d.) is a spelling and grammar check program that suggests different words when a word is grammatically correct and spelled correctly but out of context (for instance, with “I would like to meet her,” Ginger would suggest “I would like to meet her”).

Several computer-based programs exist to support the writing process; however, having many separate programs to support a pupil across planning and organizing through editing and revising can be overwhelming to the student as well as the teacher. For-purchase options do exist to support multiple needs, such as speech recognition, word prediction, and grammar checking. Two such options include Read&Write Gold (Texthelp, 2015) and wordQ+speakQ (GoQ, 2011). Read&Write Gold provides reading as well as writing support, including word prediction, speech recognition, text-to-speech, and grammar assistance (for example, checking verb tenses and homophones). Read&Write Gold is
available for Windows- and Mac-based operating systems, for Google Apps for Education, and through an app for iPads. In addition, one can purchase Read&Write Gold mobile, which contains all the software on a flash drive so it can be used with any computer rather than just one computer when the program is downloaded. The downloadable program wordQ+speechQ combines text-to-speech and word prediction (wordQ—Windows and Mac compatible) with speech-to-text (speechQ—Windows compatible).

Not all mid-tech and high-tech assistive technologies to support writing are computer based. Students can also benefit from portable word processors, although with the access to other affordable options (for example, tablets and Chromebooks), fewer portable word processor options exist. Portable word processors are battery-powered tools that include standard keyboards but smaller screens and focus on word processing features or productivity tools like PowerPoint as opposed to accessing the Internet and running separate programs. They also often come standard with other assistive technology features, such as word prediction and spell check. Examples of portable word processors include the Forte and the Fusion, both by The Writer Learning Systems (see www.writerlearning.com).

Mathematics

Mathematics can be a challenging content area for students with and without disabilities, although individuals with disabilities often lag behind their peers in terms of mathematics. The challenges students face range from fluency with basic facts to problem solving to fractions to algebra (Calhoon, Emerson, Flores, & Houchins, 2007). The most recently available NAEP mathematics assessment data support the challenge mathematics can pose to pupils with disabilities (National Center for Education Statistics, 2016). The average score for fourth-grade students without disabilities was 244, which was just below proficient on the NAEP scale of basic, proficient, and advanced. The average score for fourth-grade students with disabilities was 218, which is just above the basic level. Similar results were found for eighth-grade students: the average score for students with disabilities was 247—below the basic level—and the average score for pupils without disabilities was 282, which was between basic and proficient.

No- and Low-Tech Mathematics Assistive Technology. Although fewer specifically developed technology options exist to support students with disabilities in mathematics in comparison to reading and writing, a number of technologies are available (Edyburn, 2004). (See Table 5.4, page 141.) One of the most common low-tech assistive technologies for mathematics is concrete manipulatives. Concrete manipulatives are typically found in elementary and secondary classrooms and are considered an evidence-based practice for educating students with disabilities. Students with disabilities successfully solved a range of mathematics problems—algebra, integers, area and perimeter, and fractions—with concrete manipulatives (Cass, Cates, Smith, & Jackson, 2003; Jordan, Miller, & Mercer, 1998; Maccini & Hughes, 2000; Maccini & Ruhl, 2000).

Mid- and High-Tech Mathematics Assistive Technology. In terms of mid-tech or high-tech assistive technology, common options include calculators, virtual manipulatives, anchored instruction, and computer-assisted instruction (Bouck & Flanagan,
Research on these areas suggests technology benefits students with disabilities, although most of the research involved pupils with more high-incidence disabilities like individuals with learning disabilities (Bouck & Flanagan, 2009; Maccini & Gagnon, 2005). Calculators—four-function, scientific, graphing, and online—are one of the most common accommodations for students with disabilities on IEPs (Maccini & Gagnon, 2000, 2006). Calculators can help students with disabilities who struggle with basic facts or working memory challenges when solving word problems. Virtual manipulatives are similar to concrete manipulatives but available on a computer or mobile device through an app. In fact, almost every concrete manipulative is also available as a virtual manipulative that can do everything concrete manipulatives do but in a virtual space (that is, on a computer or mobile device via an app). The most well-known virtual manipulative website is the National Library of Virtual Manipulatives (Cannon, Dorward, Duffin, & Heal, 2004). However, other sites, such as Illuminations by the National Council of Teachers of Mathematics (n.d.) and Interactivate by the Shodor Education Foundation (n.d.), also exist (Bouck & Flanagan, 2010).

Anchored instruction and computer-assisted instruction (CAI) are less assistive and more instructional technologies that support students with and without disabilities in mathematics. Anchored instruction involves an alternative presentation (for example, CD-ROM) of a mathematics lesson or problems situated in real-world contexts. The majority of the work on anchored instruction for students with disabilities is led by Brian Bottge, and the research base supports the view that this technology helps students with disabilities in problem solving. In contrast to anchored instruction, the majority of CAI for students with disabilities in mathematics focuses more on basic facts than problem solving and is administered individually rather than in groups. However, the research on mathematics-based CAI is also generally positive (Bouck & Flanagan, 2009).

**Other Academic and Functional Performance Areas**

Outside of the two main content areas in which students with disabilities struggle, literacy and mathematics, other content domains and academic or functional performance areas can be supported through assistive technology. Although limited, some assistive technology exists in the areas of science and social studies; however, the majority of the assistive technology for these two content areas can be drawn from literacy and mathematics. Assistive technology can also benefit the instruction of life skills, and
Specific tools and devices exist that can increase, maintain, or improve the capabilities of students relative to study skills like note taking and organization.

_Science and Social Studies_. Although not exclusively, science and social studies instruction is often dominated by textbooks and other literacy-based activities, including reading and writing (Scruggs, Mastropieri, & Okolo, 2008). Hence, many of the assistive technologies discussed to support students with disabilities in reading and writing (such as text-to-speech and speech-to-text) are also applicable to support students with disabilities in engaging the content areas of science and social studies.

One science assistive technology product to note is Science Writer by the Center for Applied Special Technology (2009). Science Writer supports secondary students as they construct science reports in terms of both writing and text-to-speech so pupils can listen to what they have written. Science Writer is offered online at no cost.

_Life Skills_. Assistive technology can also help students learn life skills such as grocery shopping and food preparation. One particular category of assistive technology, self-operating prompting devices, supports students with disabilities in the acquisition of life skills. Students with intellectual disability, autism spectrum disorders, and other disabilities use such technology (for example, picture prompts, audio recorders, video iPods, or iPads) to learn life skills (Ayres, Mechling, & Sansosti, 2013; Mechling, 2007).

_Organization and Management Skills_. Executive functions, such as organization and memory, as well as self-management skills, can be beneficial to students with disabilities, who often struggle with these areas. Teachers suggest a relationship between such executive functions (for instance, meeting deadlines, following directions, or being prepared) and academic performance (McMullen, Shippen, & Dangel, 2007). Multiple low-tech through high-tech options exist to support students with disabilities in organization and self-management. Students can use common technologies such as audio recorders and other handheld devices (smartphones) to record reminders for themselves or to serve as an alarm. Specifically designed technologies for these purposes also exist, such as the WatchMinder (2015), a programmable sports watch that can set thirty alarms (for example,
“study for test” or “take medication”) and has sixty-five preprogrammed messages.

Technology can also assist students with disabilities in note taking. One common technology marketed to support anyone with note taking is a Livescribe™ smartpen. With a Livescribe™ pen, when a student writes on the specifically designed paper, he or she is not only taking written notes but can also record the conversations or lectures occurring. If a student wants to go back to his or her notes, when the student taps on a specific place on the paper, the audio will actually play from that point. The Livescribe™ pen is also only slightly larger than a typical pen. Apps for mobile devices also exist that offer features similar to those of a Livescribe pen. Two popular note-taking-based apps are Notability by Ginger Labs (2016) and Evernote (2016).

Assistive Technology and the Young Child

As previously noted, assistive technology considerations are mandated for children served under IDEA. Hence, assistive technology considerations also apply to children from birth until age 3 who are served via an individualized family service plan. While many of the assistive technology devices and tools discussed in the following chapters are applicable to young children, there are some unique assistive technology considerations. Adaptive toys and games represent one category of assistive technology (Bryant & Bryant, 2003). For example, battery-operated toys can easily be modified to work with a switch through acquisition of a copper wafer. In addition, companies are increasingly creating accessible or adaptive toys for young children, such as triangular crayons, crayon rocks, or crayons with knobs for better grasping. Young children can also take advantage of adaptive utensils or other dishes. In addition, young children are prime candidates for repurposing everyday technology and items to be assistive technology, such as a Hula-Hoop to keep objects within grasp or a cookie sheet with objects affixed with magnets.

Issues With Assistive Technology

Although assistive technology offers much potential for students with disabilities, there are challenges with assistive technology that educators need to take into consideration. Despite the benefits of assistive technology, the use of various tools and devices may stigmatize some pupils. This occurs when individuals use a technology in a general education classroom that makes them stand out or makes them feel as if they do (Parette & Scherer, 2004). For example, if a student struggles to read independently but is the only one in the class reading on a computer, he or she may feel that use of the technology is stigmatizing. Avoiding stigmatization in the selection of assistive technology is important, as feeling different can lead to assistive technology abandonment, whereby the pupil quits using the tool. Hence, when the IEP team members consider the use of assistive technology, it is important that they also examine the student’s interests, attitudes, and sense of self-confidence as well as the context in which the assistive technology will be used.

Another important issue for assistive technology is ensuring that all parties receive adequate training or possess sufficient knowledge to correctly implement the technology.
The use of technology can be overwhelming to many individuals, including students, teachers, related service providers, and parents. To help ensure successful assistive technology implementation and minimize abandonment, students, teachers, other educators, and parents need to receive training on how to use the tool as well as how to support the individual in using the tool (Lee & Templeton, 2008). Some school districts may have assistive technology specialists to support the implementation and training of assistive technology devices; however, in other situations, professionals and parents may have to rely on instructional technologies, occupational therapists, or special education teachers for support and training (Bausch, Ault, Evmenova, & Behrmann, 2008).

Cost is another challenge with assistive technology, although cost cannot explicitly be a decision-making factor (Bryant & Bryant, 2003). Assistive technology devices can run the gamut in terms of cost from free to expensive. See Table 5.7 for examples of free or low-cost assistive technology software and apps. Another consideration besides cost, stigmatization, and training issues is to repurpose everyday technology, such as iPads or Livescribe™ pens, as assistive technology tools for students with disabilities (Bouck, Shurr et al., 2012).

### Assistive Technology Future Trends

Assistive technology represents an important component of the educational services received by individuals with disabilities. Assistive technology benefits the students who need it and can help them access and succeed in the general education curriculum as well as daily living skills (for example, communication and independent living). In addition, assistive technology is one aspect that can support the implementation of universal design for learning (UDL), introduced in Chapter 1. Assistive technology can support the multiple means of engagement and expression that are critical for UDL. Assistive technology also allows for the flexibility principle of UDL to occur in classrooms.

Many assistive technologies can be used to support UDL. The Center for Applied Special Technology (CAST), for instance, has developed specific technologies in support of UDL (see www.cast.org/learningtools/index.html). For example, CAST offers the UDL Book Builder™, which allows educators to create digital or e-books to share with students. The digital books developed through this program can be embedded

<table>
<thead>
<tr>
<th>TABLE 5.7 Free Assistive Technology Examples: Software and Apps</th>
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</thead>
<tbody>
<tr>
<td><strong>Literacy</strong></td>
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<tr>
<td>Software/Internet-based</td>
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<tr>
<td>Mobile technology apps</td>
</tr>
<tr>
<td>NaturalReader (text-to-speech)</td>
</tr>
<tr>
<td>TalkTyper (speech-to-text)</td>
</tr>
</tbody>
</table>

Assistive technology allows children to engage with a variety of toys.

**universal design for learning (UDL):**

The design of curriculum materials, instructional activities, and evaluation procedures that can meet the needs of learners with widely varying abilities and backgrounds.
with characters that provide prompts and scaffolds to aid in comprehension. The digital books are also equipped with text-to-speech software. CAST also offers two mathematics-based apps to support students in mathematics reasoning: MathSquared and MathScaled (both available for download through iTunes). Aside from student-centered UDL products, CAST offers products geared toward teachers to support the implementation of UDL in classrooms, such as the UDL Exchange and the UDL Curriculum Self-Check.

In addition to even greater attention to assistive technology as a predicted future trend, assistive technology tools and devices are likely to follow the trend of all technology: mobile, personalized, smaller, and faster (Bolkan, 2012). In other words, mobile devices—such as tablets like iPads and smartphones like iPhones—will be increasingly used as assistive technology (see Table 5.8 for examples of apps for different purposes of assistive technology). Hence, students may increasingly use iPads and, for example, text-to-speech, speech-to-text, and AAC apps to participate in curriculum and everyday life activities. With the likely increase of mobile devices and apps to provide assistive technology, as well as instructional technology, teachers and other education professionals will need to become savvy consumers. In other words, educators need to think critically about apps and to validate their educational use, including those used for assistive technology purposes.

Although a standard rubric or model does not exist for evaluating apps for mobile devices for all students, let alone students with disabilities, some options do exist.

<table>
<thead>
<tr>
<th>Select Wisconsin Assistive Technology Initiative (WATI) Categories</th>
<th>Examples of Apps</th>
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</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Proloquo2Go® (iOS)</td>
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<td></td>
<td>Visual Scene Display (iOS)</td>
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<tr>
<td>Computer access</td>
<td>Dvorak keyboard (iOS and Android)</td>
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<tr>
<td></td>
<td>SwiftKey (iOS)</td>
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<tr>
<td>Activities of daily living</td>
<td>Photos (iOS)</td>
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<td></td>
<td>Moves (iOS)</td>
</tr>
<tr>
<td>Motor aspects of writing</td>
<td>Dragon Dictation (iOS)</td>
</tr>
<tr>
<td>Composition of written material</td>
<td>NaturalReader (iOS)</td>
</tr>
<tr>
<td>Reading</td>
<td>Bookshare’s Go Read (Android) or Read2Go (iOS)</td>
</tr>
<tr>
<td>Mathematics</td>
<td>MyScript Calculator</td>
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<tr>
<td></td>
<td>Base 10 Blocks (iOS)</td>
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<tr>
<td>Organization</td>
<td>Notability</td>
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<tr>
<td></td>
<td>Reminder (iOS)</td>
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<tr>
<td></td>
<td>WatchMinder™ (iOS)</td>
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<tr>
<td>Vision</td>
<td>Color ID (iOS)</td>
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<tr>
<td></td>
<td>Money Reader (iOS)</td>
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<tr>
<td>Hearing</td>
<td>FaceTime (iOS)</td>
</tr>
<tr>
<td></td>
<td>Sign 4 Me (iOS)</td>
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</tbody>
</table>

TABLE 5.8  Example Apps by WATI Assistive Technology Purpose
For example, the website learninginhand.com/blog/ways-to-evaluate-educational-apps.html offers a variety of rubrics educators can use to make decisions about apps. Educators need to think critically about the apps they are using; for example, some apps are free while others are not. Prices can vary from $0.99 to $210. There is not necessarily a correlation between the cost of an app and its quality. Although the education and special education lists on iTunes offer educators one place to start, these lists should not be taken at face value. Nor should Internet-based lists of apps for particular topics in special education (for example, functional life skills) be used without scrutiny. Educators need to read each app's description as well as carefully consider the reviews. Although apps can benefit students with disabilities, as assistive and instructional technologies they can do so only if careful attention is given to their selection and implementation, which can be time-consuming.

Chapter in Review

Technology in Education
- Multiple types of educational technology exist, including assistive technology.

Assistive Technology
- Assistive technology devices are anything that can benefit a student with a disability.
- Assistive technology services are services that support the selection, acquisition, implementation, and maintenance of assistive technology tools and devices.
- Assistive technology can be categorized by levels of technology, including no-tech, low-tech, mid-tech, and high-tech.
- Assistive technology can also be categorized by purpose, such as positioning, mobility, augmentative and alternative communication, computer access, adaptive toys and games, adaptive environments, and instructional aids.

History and Legislation of Assistive Technology
- Assistive technology was first included in the 1990 reauthorization of IDEA, although development and use of assistive technology by students with disabilities predate its inclusion in the 1990 authorization of IDEA by more than a century.
- The 1997 reauthorization of IDEA mandated the consideration of assistive technology for all students with disabilities, including students with high-incidence disabilities.

Assistive Technology Decision Making
- Frameworks exist to support assistive technology decision making by IEP teams, including the SETT framework.

Within an IEP, assistive technology supports goals and short-term objectives as a related service or accommodation.

Assistive Technology Devices
- Multiple low-tech (highlighter strips) and high-tech (text-to-speech) assistive technologies exist to support students in reading.
- Challenges with handwriting, spelling, and the writing process can be supported through low-tech (pencil grips) and high-tech (speech-to-text and word prediction) assistive technology.
- In mathematics, low-tech (concrete manipulatives), mid-tech (calculators), and high-tech (virtual manipulatives) technologies all can support students with disabilities.
- Assistive technology devices also support students in organization (Livescribe™ pens) as well as other executive functions, such as attention or memory (WatchMinder).

Assistive Technology Issues
- Assistive technology abandonment is a concern for students with disabilities.
- To minimize abandonment, IEP teams need to consider the potential stigmatization associated with use of devices or tools and ensure that students, teachers, other educators, and parents all receive the training to use the technology.

Assistive Technology Future Trends
- Assistive technology represents one way to implement universal design for learning in practice.
- Mobile devices and their apps are increasingly used as assistive technology; educators need to critically evaluate apps for their educational value.
Study Questions

1. How does educational technology differ from assistive technology?
2. What is the difference between assistive technology devices and assistive technology services?
3. Who provides assistive technology services?
4. Describe the different levels of assistive technology and provide an example of each.
5. Identify the seven different purposes of assistive technology and give an example of each type.
6. What can IEP teams use to aid in assistive technology decision making?
7. What can schools and school personnel do to avoid assistive technology abandonment?
8. What is the relationship between assistive technology and universal design for learning?

Key Terms

- educational technology, 135
- assistive technology device, 136
- assistive technology service, 136
- assistive technology specialist, 136
- augmentative and alternative communication (AAC), 137
- print disabilities, 138
- instructional technology, 140
- e-text, 144
- supported e-text, 144
- stigmatization, 150
- abandonment, 150
- universal design for learning (UDL), 151

Learning Activities

1. Search for your state’s assistive technology program. Determine what assistive technology is available through the lending library and what other resources or supports the program offers.
2. Visit several elementary and secondary classrooms in your area. What assistive technology is being implemented to support students with disabilities in content-area learning? Ask the teachers about the perceived benefits and challenges of using the assistive technology devices.
3. Visit the college or university office on your campus that provides services to students with disabilities. Inquire about the assistive technology services that are offered to students who qualify for such services. If possible, visit the area that provides assistive technology and explore the technology that is available to help students with disabilities achieve success in the classroom.
4. Search online for the free content-area assistive technology mentioned in this chapter. Explore the assistive technology online or by downloading it to a computer. Critically examine these assistive technology tools. Evaluate them for ease of use, challenges with implementation in a classroom, the benefits they may provide to a student with a disability, and if such assistive technology could be made available to all students.
Reflecting on Standards

The following exercises were designed to help you learn to apply the Council for Exceptional Children (CEC) standards to your teaching practice. Each of the reflection exercises below correlates with knowledge or a skill within the CEC standards. For the full text of each of the related CEC standards, please refer to the standards integration grid located in Appendix B.

**Focus on Curricular Content Knowledge** *(CEC Initial Preparation Standard 3.1)*

Reflect on what you learned in this chapter about assistive technology to support content-area learning for students with disabilities. As a general or special education teacher, what assistive technology would you recommend considering or discussing at the IEP team meeting if a student struggles with handwriting? Mathematical computation? Decoding words? Or staying organized and on task?

**Focus on Instructional Planning and Strategies** *(CEC Initial Preparation Standard 5.2)*

Reflect on how you use technology to support your own learning or daily living activities. How does using the technology make you feel? Does it allow you to complete your work or activities faster or easier? What if you were not allowed to use such technology—how would that impact your learning or daily life activities?

Organizations Concerned With Assistive Technology

**Assistive Technology Industry Association (ATIA)**

info@ATIA.org

www.atia.org

**Center for Applied Special Technology (CAST)**

cast@cast.org

www.cast.org

**Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)**

www.resna.org

**Technology and Media Division (TAM), Council for Exceptional Children (CEC)**

contactus@tamcec.org

www.tamcec.org

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