A chapter on computer-based assistive technology is necessary to this report because access to computer technology in today’s classroom can provide teachers with such a wide range of tools to make inclusion possible and easier. Many “built-in” assistive technology features turn out to be advantageous for a broad range of individuals, not just those with special needs. Indeed, if teachers can build supports and scaffolds necessary to ensure progress for all learners – such as assistive technology – into their instructional methods and learning materials from the very beginning, all learners will benefit from less need for remediation and fuller participation in the regular curriculum (Hitchcock, 2001).

Assistive technology plays an important role in the provision of instruction based on universal design. In a universally designed classroom, teachers can provide students with the tools necessary to adapt methods and materials to their individual needs, flexible goals for learning, and continuous assessment (Hitchcock, 2001). Teachers can support all students with equitable access to all aspects of the learning experience – equal access to the curriculum where this would otherwise be not possible or very difficult, and equal access to the tools needed to access the curriculum. The positive impacts of assistive technology on the development of even very young children are demonstrable (Judge, 2001).

**What assistive technology is – and is not**

Assistive technology is any technology that allows one to increase, maintain, or improve the functional capabilities of an individual with special learning needs (Edyburn, 2000). Its applications and adaptations can help open doors to previously inaccessible learning opportunities for many children with special needs (Judge, 2001).

Assistive technology differs substantially from other types of technology that assist students. Instructional technology, for instance, uses innovative tools such as videotapes, computer-assisted instruction, projectors, multimedia effects, sound enhancement, and the Internet to expand the instructional modalities in the classroom, without regard to specific students’ needs. Assistive technology also differs from assistance such as wheelchairs, hearing aids, and glasses for vision, which are, of course, essential to the students who require them.

Some assistive technology changes the environment so that a person can function (adaptive technology); some technology adds qualities to the environment (augmentative technology).
Tools to Help All Students Learn More Effectively

Computer programs are designed to perform one or more particular tasks or functions. To this end, each computer program contains a variety of features. Assistive technology computer programs are fitted with particular features designed to assist specific functions – for example, a feature that will help with word finding. As a result, providing students with assistive technology software is akin to providing them with a “toolkit” for assistance specific to their needs.9

Thus, tools provided with a software program can have greater and wider impacts on learning than the complete software program. When evaluating any computer software program, therefore, it is more important for the teacher to ask “what tools will the student(s) need in order to be able to function (e.g., write more effectively)” than to request a particular program, which may lack the level and combination of features (tools) that will allow or encourage the student(s) to function with any degree of independence.

In a general education setting, computer-based assistive technology can provide students with:

- access to information;
- computer-assisted instruction;
- drill and practice;
- training;
- organizational strategies;
- the ability to publish;
- functional skills, such as keyboarding and computer skills;
- study strategies;
- unique experiences, such as multimedia.

In addition, using computer-based technology is desirable for the following reasons:

- Drill and practice tasks can be less monotonous on a computer than with pencil and paper.
- Using the computer in school is a part of school activities. It can be integrated with other school activities, rather than requiring withdrawal from the classroom.
- Students often see computers as non-threatening. Being corrected by a computer can be far less threatening than being corrected by another person.
- Computer use can assist in the development of a functional skill, and can also provide structure and give immediate feedback.

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9. The Ontario Software Acquisition Program and Committee (OSAPAC), at www.osapac.org, provides a list of licensed software available from the Ministry of Education. Every school board has a representative that can assist teachers in accessing the software.
How Assistive Technology Can Benefit Students

Technology, of course, is not the answer to all the problems faced by students with special needs. It is necessary for some students in the same way that eyeglasses or other aids are necessary for some students. Its successful use in the classroom will depend on the characteristics of individual students; the outcomes that students need to accomplish; the task that meets the needs of a particular student; and the functional use of the hardware and software.

Nonetheless, the literature provides plentiful evidence that assistive technology can effectively help students with special needs to:

- build on individual strengths (Lewis, 1998; Martin, 1998);
- benefit from using a compensatory tool (Lewis; Martin);
- gain motivation (Martin);
- accomplish higher rates of learning and improved achievement (Martin);
- complete academic tasks independently, including tasks they might not otherwise be able to handle unaided, leading to a greater sense of self-efficacy (Polloway, Smith, & Patton, 1988).

Specific Benefits for Literacy and Numeracy

Assistive technology can specifically address reading, writing, and numeracy challenges (Edyburn, 2000, 2003). Among its capabilities are the following:

- **Word processing** can address fine motor difficulties and reduce messy work.
- **Spell-checking tools** can reduce some spelling difficulties.
- **The ability to place graphs and charts in assignments** can allow students to produce a better quality of assignment, reinforcing the value of published writing.
- **Cut-and-paste** features in word processors allow students to manipulate text easily when editing, saving valuable time and effort. The physical process and effort of rewriting work can be laborious, time consuming, and fatiguing for some students.

Limitations of Assistive Technology

**Computer-based assistive technology is not a panacea.** Students receiving special education programs and services usually have a number of areas of need. It is unrealistic to expect one or even several software programs to address all of a student’s learning needs.

**Complex solutions are not always the best solutions.** The more tools that are embedded in a program, the more complexities the student, and the teacher, has to learn, unlearn, and set up. More often than not, the student needs only one assistive tool. The keep-it-simple “toolkit” approach (e.g., Puckett, 2004) will serve teachers best. The simpler, cheaper program may be the more appropriate than the spectacular “does-it-all” program. (For more details on assessing assistive technology, see Raskind & Bryant, in press.)
No one solution will address all learning and productivity issues. Even if a particularly persuasive vendor approaches an educator repeatedly with claims of the “perfect solution”, that solution may not have the tools the teacher requires to support the specific learning challenges.

Not all assistive technology tools are appropriate for all students with learning challenges. One would not prescribe eyeglasses for a child who requires a support for hearing. Similarly, for every student, it is important to identify curriculum tasks and outcomes, evaluate barriers to accomplishing those tasks, and match the characteristics of computer technology with the student’s individual learning profile.

Students need basic keyboarding skills to maximize the effectiveness of assistive technology. Basic keyboarding skills will affect any student’s accomplishment with computer-based technology – even for those using speech recognition systems (see Edyburn, 2003; Higgins & Raskind, 2000).

Assistive technology does not replace the teaching and learning processes. It is a tool that is used to support teaching and learning.

Assistive Technology Tools to Support Students With Special Needs in Reading

A wide range of software tools supports reading across different learning abilities and styles. Three specific types of effective technological supports are Optical Character Recognition (OCR) for scanning text, speech synthesis of text, and the thesaurus found in most word-processing programs. This section provides details on OCR and speech-synthesis software.

Optical Character Recognition (OCR). OCR software allows students to scan reading material into a computer and then see only the text from the scanned material on the computer screen. It essentially separates the text from any pictures in the text and converts text information into a text format. It requires a scanner (handheld scanners can only scan limited lines of text), word-processing software, and specialized OCR software. It is important to note that some OCR software is better than others. In general, OCR software should maintain formatting, such as page layout and graphics that may be important for working with the text. It should also handle columns effectively and interpret print reliably.

Speech synthesis (screen readers, or read-back software). Speech synthesizers are basically screen readers. They read text that is displayed on the computer monitor, allowing students to gain independent access to assignments, books, and research. Teachers or students do, however, need to pre-scan material before they can use it.

For some students, OCR software combined with a screen reader provides their first opportunity to enjoy literature. In addition to a scanner and word-processing software, students require headsets so they can listen to reading passages without disturbing others.

These two technologies combined can be particularly helpful for students who have relatively few problems comprehending spoken language but have great difficulty with decoding of text. The research demonstrates that OCR and speech synthesis reduce frustration in decoding and allow for more complete comprehension of text (Lundberg, 1995; Montali & Lewandowski, 1996).
In addition, several researchers have noted that the use of this technology can actually improve word-recognition and decoding skills (e.g., Higgins & Raskind, 2000; Olson & Wise, 1992; Torgesen & Barker, 1995). One longitudinal study in particular (Lundberg) demonstrated improved word recognition and spelling in students with lower scores in these areas as compared with a control group not supported by computer use.

For students who can handle the content of any given subject or course, the use of OCR and speech synthesis allows them to access the print in textbooks, and thereby the curriculum, in a way that would otherwise be more difficult, if not impossible. It may even increase student motivation to read (Montali & Lewandowski, 1996).

### How students can use speech-synthesis software

- Where text is available in digital form (i.e., on the computer or diskette), students can have text read to them.
- Some screen readers can read in a variety of applications, including the Internet.
- Some Internet sites have collections of textbooks available to be read by screen readers.
- Students can control the pace of the reading and the reading selection, through having the computer read only the words they are having difficulty decoding or a whole paragraph or passage.
- Students can manipulate the rate of read-back to allow for variations in the speed they process auditory information.

### Assistive Technology Tools to Support Students With Special Needs in Writing

Likewise, a wide range of software tools supports writing across different learning abilities and styles. These include the thesaurus and publishing tools such as graphics and multimedia capabilities, now widely available in word-processing programs. This section provides a detailed look at more specialized software that enables:

- word prediction;
- planning and organizing;
- specialized (aural, or dyslexic-style) spell check;
- speech synthesis (text to speech);
- speech recognition (spoken word to text).

#### Word-prediction software

Word-prediction software can be installed on computers that run word-processing software. It has been found to be the most effective tool for assisting written expression (Laine, 1999; MacArthur, 1998).

Programs that contain this feature display a window that lists high-frequency words as the student types. Once the student types the first letter, the highest-frequency words beginning with that letter are displayed. Most often, four to nine words appear. Then, when the student
enters the second letter, the screen lists high-frequency words starting with the first two letters. As the student continues to type, most word-prediction lists continue to narrow the number of possible selections based on the additional letters. The student can select the word he or she is trying to spell once he or she sees it, and it will appear in the student’s text. The words the writer uses are saved as he or she uses the tool. That way, the student builds a personalized word list over time.

Among the many variations of word-prediction software available on the market, there are:

- programs that read the word choices displayed, thus providing both visual and aural assistance;
- programs that try to predict what the student might write next, based on syntax and spelling;
- programs that are marketed as “word-prediction” programs but are only “word-completion”. Some programs try to predict the next word in the sentence based on the previous word. For example, if the student types “The c_”, the program responds with “c” nouns. Word-completion programs respond by providing all common “c” words;
- programs that are integrated with a word-processing program. Students who use these programs may have to learn a word-processing program that differs from the word-processing program with which they are familiar.

Word prediction does not give the user “the answer” to any question. This tool essentially provides students with an immediately available vocabulary list, speeding up the writing process by allowing writers to find the most appropriate word (see Wiig & Semmel, 1980).

Word-prediction technology also can reduce spelling mistakes, increase motivation, and help students who have difficulty with the physical act of writing.

MacArthur (1996) found that word prediction can make a significant positive impact on the writing of students with severe spelling difficulties. Word prediction offers an independent method for word finding and self-monitoring for these students, because they only need to know the first letter of a word in order to use it in their work. Other case studies show that word prediction can increase the quantity and quality of work in addition to improving spelling (e.g., MacArthur, Ferretti, Okolo, & Cavalier, 2001).

To make the most of this tool, MacArthur’s studies suggest that:

- teachers need to pay careful attention to students’ skill, the design of the word-prediction tool, and the match between this technology and the task;
- teachers should be aware that students whose oral skills are extensive or esoteric do not find word prediction as useful as students whose vocabulary is more limited;
- teachers need to encourage students to extend their vocabulary and not rely repeatedly on the same words;
- younger students should use word-prediction programs with a smaller vocabulary;
- teachers should consider selecting a word-prediction program that allows students to program specific vocabulary for the task.
Software for planning and organizing

Students with special needs often have difficulty organizing themselves in writing – a skill essential for high-quality written work, especially from junior years to secondary school (Graham, 1999). Software programs that help students organize and thereby structure their writing are usually visual in nature, allowing students to:

- create thought webs or cognitive maps that emphasize relationships between ideas;
- manipulate categories of ideas and place them where they think appropriate;
- see an outline of the topics and subtopics of their writing. Students can easily manipulate and reorganize the text at any time, allowing them freedom to express their ideas without worrying about categories;
- use one of the numerous templates already prepared and organized so that all they have to do is fill in the information in the appropriate area. Teachers who want students to follow a particular method or structure in an assignment can create a template for students to follow.

Most speech-recognition programs work within this software. As with all software, teachers need to understand it and its effective use. They need to provide explicit instruction on how to use the software (Anderson-Inman, Knox-Quinn, & Horney, 1996) and monitor the ways students use it. Otherwise, students may, for instance, spend more time playing with the graphic features of the program than on organizing and writing (Bahr, Nelson, & Van Meter, 1996).

Specialized (aural or dyslexic-style) spell-check software

Some students experience a great deal of difficulty with spelling. A good body of research (see Sitko, Laine, & Sitko, 2005) shows that traditional spell checkers available in virtually all word-processing programs are a useful tool for both good and poor spellers. They allow students to see some mistakes, and to choose the correct spelling from a number of options. But they only catch mistakes if the misspelling is somewhat close to the correct spelling. Also, they fail to red-flag homonyms or other “real” words that are misspelled in context.

Dyslexic-style spell checkers, on the other hand, check for reversed letters (b and d, a and c, p and q), missing first letters, and dyslexic-style phonetic errors, such as an f for ph. They display and can read aloud the spelling options. Some allow students to listen to the options available, speak meanings on homophones, and can allow students to program in unusual spellings that most spell checkers would not pick up. There has, however, been no research on whether these are more useful than traditional spell checkers.

Speech-synthesis (text-to-speech, or read-back) software

This tool, which converts text on the screen into aural speech, is as useful for effective writing for individuals with cognitive and communicative impairments as it is for assisting with reading. Hearing the text that one has produced can encourage increasing independence in self-monitoring one’s writing (MacArthur et al., 2001). Speech synthesis has also been instrumental in improving spelling in some students with special learning needs (Sitko et al., 2005).
Speech-recognition (spoken-word-to-text) software

Speech-recognition software is a fairly affordable tool, and works with most word-processing systems. It allows students to dictate, into a microphone headset, what they want the computer to type. The student trains the computer to recognize his or her voice patterns and pronunciations by reading it material provided by the software for 30 minutes to several hours. The more a student uses the program, the better it gets at recognizing that student’s voice – eventually reaching better than 90 per cent accuracy.

Designed for users with good communicative or cognitive abilities, or good visual vocabulary skills, speech-recognition software has found many disciples in the field of special education over the past five or so years. It can be particularly helpful to individuals whose oral language skills exceed their written production. Although speech recognition is most useful for students who are verbally fluent, with daily, supervised use it can also have a positive influence on the performance of less verbally fluent students (Wetzel, 1996).

While its many potential benefits can be good for some students, careful assessment of a student’s abilities is essential before acquiring and implementing this technology. Current researchers have not come to a consensus about the effectiveness of using speech-recognition systems as a tool for students with special needs (Lords, 2001), and most research work on the use of this technology has been conducted with older students and adults.

Among its potential advantages are the following:

- It allows students to get their ideas down where this would otherwise not be possible.
- It allows students to write more fluently, and can improve spelling, reading comprehension, and word-recognition scores (Higgins & Raskind, 2000).
- For some students, it can be significantly faster than writing or typing (De La Paz, 1999).
- It allows students to use longer and more complex compositions with fewer grammatical errors as compared with other methods of written production.
- It demonstrates commensurate improvement in achievement for some students (Graham, 1999). Graham found that not only did students attempt to write down vocabulary they had avoided because they had previously been unable to spell it, they were able to work at a faster pace and therefore get down words they might have forgotten due to slower typing or writing speed.
- It allows students to see and review their dictation and use what is on the screen as a cue for remembering their thoughts (Wetzel, 1996).
- Once the laborious nature of writing is eliminated, students are more motivated to write (Graham, 1999).

Some of the improvement in the quality of the student’s writing, it has been hypothesized, is a result of the student’s need to attend carefully to what is being written on the screen. If the program makes an error, students are presented with, and must read and select among, several choices, and then use a command to correct the mistake (Forgrave, 2002).

There are, however, compelling reasons for teachers to exercise caution when considering the use of speech-recognition software.
It can be extremely time-consuming – for both students and teachers. All major researchers of this technology have shown that the attention of an aide (either a teacher or other support staff) increases the benefits gained. Initial training may require the student to read into the computer for laboriously long periods of time. An instructor will need to work with students who are not able to read the passages fluently. The instructor has to read one phrase at a time to the student, and have the student repeat that phrase back into the microphone, carefully ensuring that the instructor’s voice is not picked up by the microphone. Furthermore, students with a reading disability may not be able to tell when they have made a mistake. In order to get the program working well with such individuals, an instructor must work with students one-on-one in the initial stages of using the program before allowing them to be independent.

Even after successful initial training, the program will make some mistakes. In order to use the program independently, students must learn and use the appropriate commands to inform the program every time it makes a mistake. Should students continue to ignore mistakes, the accuracy of the program will decrease.

Students must be aware of idiosyncrasies when dictating to the computer. The student must learn to “pause” the program when he or she wishes to talk or ask a question aloud.

Visual fatigue can set in. This lowers the effectiveness of the program when students use this tool for extensive periods of time (Wetzel, 1996). Alternating between voice and keyboard can be an important strategy for some students.

The technology may be too complicated for use by many students in a typical classroom setting. Each student has a personalized “voice file”. He or she is responsible for opening this file when entering the program and saving this file when exiting it. In the “multiple-user” situation of the average classroom, there is a danger that a student may inadvertently use another student’s voice file, thereby corrupting the file.

### Assistive Technology Tools to Support Students With Numeracy Challenges

There are numerous non-technology programs and tools that assist students in mathematics, such as manipulatives or concrete tools. Students with numeracy challenges can also benefit greatly from assistive technology.

There are, for instance, a wide range of calculators with capabilities well beyond those of the traditional pocket or graphing calculator. Students can use:

- talking calculators that vocalize data and resulting calculations through speech synthesis;
- special-feature calculators that enable the user to select options to speak and simultaneously display numbers, functions, entire equations, and results;
- specialized hand-held calculators that can help a learner who has problems writing numbers in the correct order;
- on-screen computer calculator programs with speech synthesis;
- large display screens for calculators and adding machines.
Other possibilities include:

- math overlay for specialized keyboards;
- software that allows students to manipulate objects and geometric shapes;
- assistive technology that assists in reading and writing for literacy-related tasks in mathematics (word-prediction programs can be customized to recognize math terms);
- electronic math worksheets;
- speech synthesizers;
- internet math games and math sites for the development of numeracy skills;
- alternative keyboards for numeracy;
- colour coding for maintaining columns;
- big number buttons and large keypads;
- textbooks on CD-ROM;
- videotaped math lessons;
- computer-assisted instruction.

Websites focused on mathematics, such as www.nctm.org, or sites related to learning difficulties, such as www.schwablearning.org/index.asp, suggest additional tools.

**Assistive Technology Tools to Support Students With Language Challenges**

Any software that encourages the use of language skills, grammar skills, and vocabulary development using a variety of techniques — such as videos, audio, games, computer-assisted instruction — can help all students. Specialized software containing tools that will enhance receptive and expressive language learning are also available. Most of these programs were originally designed for very young learners but have been found useful for developing literacy skills, especially for students who have English as their second language. They normally feature picture symbol representations with, or in place of, words; speech synthesis that will allow verbalization of graphics and symbols; and/or tools that allow the student to make and/or use “talking books”.

**Assistive Technology Tools to Support Students With Sensory Challenges**

Closing the Gap (www.closingthegap.com) is the largest organization related to learning and assistive technology in the world. It provides a significant directory of hardware and software appropriate for students with sensory challenges, such as:

- electronic braillers;
- electronic viewers that can magnify text and images on the screen and provide diagrams from various perspectives;
- Picture Exchange Communication Systems (PECS) symbols that are designed to assist communication in social contexts;
• Math Braille Talk, which allows the user to input mathematical terminology and diagrams vocally and have them come out as braille;
• videos that allow for closed captioning and for training.

Assessing the Quality of Assistive Technology Tools

There is little doubt that computer technology can provide some students with a powerful alternative method for demonstrating learning (e.g., multimedia, PowerPoint presentations, publishing software). Teachers should be encouraged to use a variety of technologies in their teaching, including assistive technology, to ensure the best possible student outcomes. In many cases, the assistive technology is an assessment accommodation for the student and must be provided during assessment and evaluation activities. But how does a teacher know if any assistive technology can help a student function more effectively in the classroom, or in a particular subject? There are many organizations to help a teacher find out, such as Closing the Gap and the National Assistive Technology Research Institute, based at the University of Kentucky. But for a quick assessment of the quality of a particular assistive technology tool, Table 16 may help.

Table 16. Assessing the Value and Usefulness of Assistive Technology

Consider each of the following “quality indicators” and check off the box that most closely describes the rating you would give a particular assistive technology tool with respect to each indicator. These indicators are by no means exclusive or exhaustive, and your assessments may differ from those of another teacher.

The completed table will help you identify barriers or next steps to improving students’ ability to demonstrate learning in your classroom.

<table>
<thead>
<tr>
<th>Quality indicator</th>
<th>Unacceptable (= 1)</th>
<th>Somewhat useful (= 2)</th>
<th>Acceptable (= 3)</th>
<th>Very useful (= 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of independent use by the student</td>
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<td></td>
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<tr>
<td>Alignment with curriculum expectations</td>
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<tr>
<td>Usefulness for task completion</td>
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<tr>
<td>Ease of use</td>
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<tr>
<td>Accessibility of equipment</td>
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</tbody>
</table>
Where We Go From Here

Are we using assistive technology effectively? This is a critically important question. The National Assistive Technology Research Institute is asking important questions to try and help us answer it:

- **About students:** What are students’ needs and abilities? Why does a student need assistive technology? What are the major areas of concern that need to be addressed?

- **About the learning environment:** Where and when will the student use assistive technology? What supports and resources are available? How can the computer be accessed for ease of use for student learning and instructional demands?

- **About tasks:** What does the student need to be able to do that is difficult for the student at this time? What is the expected level of independence?

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**A teacher and classroom may be ready for computer-based assistive technology when:**

- **the teacher can answer “yes” to the following statements:**
  - I am trained and able to use assistive technology.
  - Appropriate and effective hardware is available and accessible.
  - Everyone involved understands what is happening and why.
  - I can access ongoing support.
  - I know the strategies that must be taught to the students.
  - I have positive perceptions and attitudes towards electronic tools.

- **the teacher can provide an informed answer to these questions:**
  - Why do I want or need computers in my classroom?
  - What do I want them to do (that I could not do without them)?
  - What will they do for my students?
  - What are the (programmatic and curriculum) outcomes we must expect from their use?
  - What (new/extra) skills will the students need in order to use them?

- **the teacher can address these key instructional issues:**
  - How will this specific assistive technology affect what I do (the way I teach, assign, and evaluate)?
  - How will this assistive technology affect what the student does?