Chapter 15
Use of Technology for Literacy Acquisition Among Children with Communication Difficulties

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Children need communication to develop within a society and to maintain knowledge. They are dependent on their ability to comprehend, manipulate the environment, and transfer information for their development. In a literacy-based society, they also need to have a command of reading and writing. Language development is often impaired among children with special needs, especially those who have communication difficulties, such as children with physical impairments, intellectual disabilities, and developmental disabilities such as autism spectrum disorder (ASD). Their reading and writing skills tend to fall far behind, even in relation to their cognitive and educational abilities (Dahlgren et al. 2010; Foley 1993; Sturm and Koppenhaver 2000). While communication difficulties may inhibit children from learning language and literacy skills, technologies may assist and enhance opportunities to overcome those difficulties. This chapter will address some of the uses of this wide range of technologies that have been developed to enhance literacy skills by children with communication difficulties and reflect on the existing technologies and on the need to develop systematic instruction to enable skillful understanding of its potential.

Typically, developing children master language and demonstrate communication competence by the time they learn to read and write (Nelson and Kessler-Shaw 2002). However, for children with communication difficulties, this is not the case, as they often develop language abilities and literacy skills concurrently (Mineo Mollica 2003). Although it might seem as if one has to have some level of competence in language prior to attempting to resolve the puzzle of associating phonemes and the arbitrary graphic symbols we call letters, children with communication difficulties often depend on learning literacy skills for gaining competence in their language skills. Yet, language acquisition is an essential building block, critical for

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acquiring reading and writing. Language acquisition demands an ample amount of resources for building and establishing it as a foundation for literacy learning. Thus, children need to have an understanding of language and its rules, as well as sufficient vocabulary to unwrap the secrets of literacy. As speech is often impaired in children with communication difficulties, the use of other resources, such as literacy, is needed for gaining communicative competence and enriching vocabulary. Thus, some of these children use graphic and orthographic symbols for language learning as well as for mastering literacy skills (Smith 2005). This process of enhancing and enriching language competencies while learning to read and write is reciprocal and pertains also to typically developing children.

Language impairments preventing practice of new words as well as physical impairments preventing access to printed material have been found to be strongly related to reading and writing difficulties later detected in school-aged children (e.g., Kamhi and Catts 1986; Sevcik et al. 1991; Smith 2005; Wolff Heller and Coleman-Martin 2007). These difficulties that begin long before school starts become noticeable during preschool and kindergarten years. These barriers inhibit the child's exposure to opportunities for developing emergent literacy skills and later on reading and writing (Koppenhaver and Williams 2010; Koppenhaver and Yoder 1993).

One of the most important ingredients in the process encompassing language and literacy learning is the opportunity to develop, train, enrich, and practice knowledge gains over time (Hetzroni 2004; Smith 2005). Reading and writing usually do not develop naturally among children. Yet, those tools are critical for succeeding in the academic literacy-based society (Koppenhaver and Yoder 1993; Lonigan and Shanahan 2010). Children who have the opportunity to practice and enrich their knowledge at home and at school succeed in gaining a rich language, adapted to their abilities, learn to read and write, and use those skills to maintain academic achievements and an understanding of social codes (e.g., McKeough et al. 2006). Yet, for children with communication difficulties, obstacles may impede opportunities for normal literacy development. Those obstacles may result from physical limitations, cognitive disabilities, technological difficulties, and/or environmental barriers, as well as low expectations (e.g., Browning 2002; Kopenhaver and Erickson 2003; van Balkom and Verhoeven 2010).

Physical limitations may prevent a child from accessing a book and prevent opportunities to interact with written material, choose or select a desired story, or question an unclear topic (Koppenhaver and Yoder 1993). Physical difficulties, as well as developmental disabilities, often accompany language impairments. Those difficulties can encompass additional challenges such as preventing children from asking questions, clarifying a point of interest, or even requesting parents to read a favorite story (Hetzroni and Schanin 2002). Complex difficulties can prevent a child from viewing the text or hearing the story, understanding messages, or creating the needed associations for building upon common knowledge gains. Such difficulties also have an impact on the communication partner who tends to develop low expectations, speaks slower using limited vocabulary, refrains from using long and complex sentences, uses simple language, and limits conversation mainly for basic

needs (Erickson and Koppenhaver 1995; Erickson and Sachse 2010; Fewell and Deutscher 2004). Additional cognitive impairments tend to delay language development and reduce exposure to literacy even more. As these children grow up, the gaps between them and typically developing children increase, and, thus, their distinctive needs expand.

The Technology of Graphic and Orthographic Symbols

Over the years, many strategies have been developed for teaching, reading, and writing. Some of the strategies incorporate the use of graphic symbols (see Fig. 15.1) for supporting orthographic symbols (i.e., alphabet letters). Those graphic symbols, used often in language acquisition, assist in associating between language and literacy, thus enhancing reading and writing acquisition and comprehension (Preis 2006; Sevcik et al. 1991; Sturm and Clendon 2004; van Balkom and Verhoeven 2010). Graphic symbols have also been used for the past few decades for teaching language and for enhancing and augmenting communication among children with communication disorders (Romski and Sevcik 2005; Soto and Hartmann 2006; Zangari et al. 1988). Many sets and systems of graphic symbols currently exist; some are more iconic, such as pictures of known objects, and some are opaque, such as line drawings of emotions and actions (see Lloyd and Kangas 1994; Mirenda 2001 for detailed information).

Augmentative and alternative communication (AAC) is a theory-based set of methods, technologies, and strategies, used for enhancing communication of individuals that do not develop it naturally (Lloyd and Kangas 1994; Mirenda 2001). AAC enables use of multisensory channels, such as visual and tactile, in addition to the auditory channel (speech) usually used for communication. It allows adaption of speed and level of message comprehension to the ability of the user and matching types of symbols to the user's needs (Koppenhaver and Erikson 2009).

Symbols used for delivering messages are usually transferred using auditory channel (speech) or visual channel (written text). However, when speech cannot be used as a preliminary form of transmission, reading and writing become even more essential as a verbal form of communication. When those are difficult to achieve, other methods should be considered. In such situations, pictures, drawings, and even objects can be used to convey messages and to enhance communication. Such methods should be adapted to the needs of the user and then used for applying and reinforcing the process of language and communication development (van Balkom and Verhoeven 2010). Symbol sets and systems have been developed over the past decades in order to assist in language acquisition and in the development of literacy skills (Fuller et al. 1992).

Graphic symbols represent ideas visually, have a varying degree of translucency, and can be used for conveying messages by individuals with different abilities (e.g., Angermeier et al. 2008). For example, a picture of one's mother can represent the concept "mother," a drawing of a cup can represent "I want to drink," and an abstract

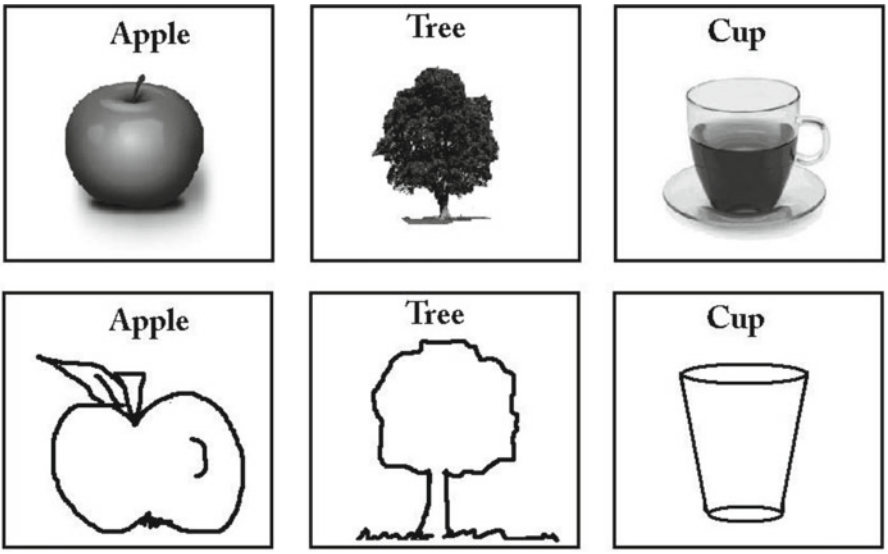

Fig. 15.1 Example of graphic symbols

line drawing can represent emotions such as "love" or "sadness" and concepts such as "dream" or "mind." Some graphic symbols have a wide set of rules that underline the logic of the system used for making them. Others have limited rules (Binger and light 2007). Orthographic symbols, such as the alphabet letters, are also abstract arbitrary symbols that require significant learning of the rules and the system underlying the logic behind them. They do not make sense until the rules are mastered through practice and understanding.

Several studies investigated use of graphic and orthographic symbols for different populations, addressing issues such as speed and learning efficiency and use and adaptation for the different needs of the users (e.g., Hetzroni and Lloyd 2000; Hetzroni and Ne'eman in press; Koul et al. 2005; Mizuko 1987; Schlosser 1997). Exposure to the symbols has been found to be effective for language acquisition and for preliminary exposure to its written form (Bishop et al. 1994; Jones et al. 2007; Sevcik et al. 1991). The printed graphic symbols (usually accompanied by written explanation of the symbol) can create a preliminary link between communication, language, and the symbols representing them, increasing understanding of the power of the word and its control over the environment. Graphic symbols, paired with printed words, were used in a study using stories presented to five kindergarten children with autism (Hetzroni and Ne'eman in press). The children learned the stories using a computer-based program in which they were exposed to the stories and to educational games teaching them vocabulary and symbol identification. By the end of the program, those children were able to identify most of the symbols and answer short questions about the stories. The stories used in the study were narratives of their daily activities, thus creating a link between the symbols, their meaning, and

their everyday activities. Exposure to the material, adjusting over time from one symbol to several symbols representing several ideas, creates an understanding of the relationship between the sequencing of the symbols and the ideas they represent. Understanding the relationship between the symbols and the need to encode them creates a parallel to the encoding process and the rules that govern reading, thus building a basis for understanding literacy (Bishop et al. 1994). Building this power of understanding will later assist in manipulating literacy and using it to succeed within family, community, society, and work.

Assistive Technology

Any tool created to assist, enhance, preserve, or scaffold the functional abilities of individuals with special needs can be referred to as assistive technology (AT). The various applications that are currently available enable both teachers and students to enjoy the technologies that assist them in resolving their educational teaching and learning needs (King 1999). AT includes a wide range of unique and standard technologies aimed for improving the ability to learn, expand accessibility, and increase opportunities (Kaye et al. 2008; Lewis 1993). Tools ranging from chalk and ink, paper, and notebooks to word processors, calculators, computers, tablets, and smartphones that are used today can be referred to as AT. Using AT can compensate for severe difficulties and assist in communicating with the world, repair visual and hearing impairments, and rehabilitate damaged organs (Scherer 2002). Technologies such as cochlear implants, text enhancers, computers that can read aloud written text, as well as switches and voice-output communication devices have empowered many individuals, increasing their abilities and their quality of life.

The field of AT includes various types of technologies adapted to fit a wide range of needs, targets, and functions. Some of the technologies are basic (e.g., Edyburn 2000; Wasson et al. 1997); others are very complex (e.g., Koul et al. 2005; Quist and Lloyd 1997). Basic AT are usually compiled of simple means, easy to obtain and maintain, while complex AT include intricate and complicated technology that are more expensive and difficult to assemble, maintain, and obtain, thus requiring an understanding in the nature of the tool (Campbell et al. 2006; Cook and Hussey 1995). Basic AT may include a wide range of tools such as communication books, charts, basic switches and tape recorders, pointers, and even cards and folders with symbols drawn on them, colored markers, and rulers. Complex AT range from computers and speech-generating devices (SGD) to cochlear implants, complex mobility tools or handheld computers, tablets, smartphones, and virtual reality systems.

Over the years, with the adaptation of technology and the expansion of its use in education (Grabe and Grabe 1998; Watson et al. 2010), changes in the field of technology have enabled the development of tools that are complicated and complex, specific yet elaborated (Edyburn 2000; Hetzroni et al. 2009; Hetzroni and Shrieber 2004), which enables access of these resources by a wider range of populations. This development enhanced the creation of tools that have unique qualities,

designated to serve the needs of individuals with communication difficulties as well as other populations with special requirements (Campbell et al. 2006).

The computer, for example, has developed over the years to become an effective tool in the educational system, effective for learning, obtaining knowledge, practicing, investigating new fields, exploring, simulating, and expressing new ideas and thoughts (Flippo et al. 1995; Judge and Lahm 1998; Judge and Parette 1998; Kozma 2003; Parette and Stoner 2008). Computer use is executed through input and output peripherals, ranging from the traditional mouse and keyboard for inputting and manipulating information and a screen and printer as output channels to more complex input and output measures such as speech activation, text enhancement, and touch screens. However, it seems as if those mechanisms, usually readily available for common use in most computer systems, remain a hidden secrete from many individuals with special needs that could benefit from using them. Research has demonstrated that exposure to the advantages of computer use as well as consistent dedicated instruction to the staff working with those individuals can increase use and expand the knowledge in the practical and technical aspects of using these technologies (e.g., Hetzroni and Ne'eman 2010).

Computers suffice use of traditional input and output peripherals in the educational system. However, for children with special needs, these input and output methods are often not enough (Lahm 1996; Lahm and Sizemore 2002). For example, physical difficulties may prevent the use of conventional input modes. Hearing or visual impairments may hinder use of auditory or visual modes of output. Cognitive disabilities or visual impairments may limit the abilities of encoding the text displayed on the screen. More so, the specific needs of each child require unique resources and specifications that evoke large expenses and make the programs complex, too specific or difficult to produce. Different needs also elicit various computer access solutions. For example, the need to access relevant information from the Internet may require modifications, either in content and language or in unique input and output devices.

Children with autism, for example, require unique adaptations (Pennington 2010). If the child has difficulties in retrieving information and using functional speech, a suitable SGD might be appropriate for use. However, this device should be light in weight, easy to carry, versatile and yet sturdy, complex in the number and type of messages it can produce, and adapted for the educational needs. More so, this device should have the capacity to be modified over the years, to be converted from one symbol system to another, and to be assisted in acquiring literacy skills. If the child has the capability to select directly, a computer-based system using a touch screen that is light enough to be used as a handheld computer and elaborate enough to satisfy the varying needs would be appropriate. On the other hand, children with physical disabilities that have communication difficulties due to their physical impairment might need to access SGD using switches adapted to their need (Beukelman and Mirenda 2005). For those children, literacy may not only be a key for academic achievement but also their access to communication and survival in the environment around them.

The unique individual needs described above intrigued the industry to use open tools that are flexible and adaptable enough for these unique needs. The industry has also begun to look at the needs of the child within the educational system when tending to the AT specifications (Watson et al. 2010). Computers, peripherals, and software programs can scaffold the educational process by creating a supported environment individually adapted for each child's needs. Thus, the computer can provide for active learning in a controlled environment tailored to the needs of the child, based on the specifics of their educational needs and abilities.

Literacy and Assistive Technology

One of the first challenges a child in the educational system faces is the need to learn to read and write (Kofsky-Scholnik 2002). The child is expected to develop competencies and sufficient literacy skills to enable success in fulfilling the requirements and adapting to the educational system. Research has investigated various ways for acquiring literacy skills among children who have varying difficulties using a wide range of technologies (e.g., Hetzroni et al. 2009; Hetzroni and Schanin 2002; Wilkins and Ratajczak 2009). The development of AT, especially computers, has broadened the range of educational possibilities, creating optimal tools adapted to the needs. The use of AT can enhance abilities and enable success. Using these technologies over time can improve abilities and assist in transforming acquired knowledge for use while learning to read and write (Lewis 1993). While some of the children will need to continue using AT all the time, others might be able to, after acquiring the required skills, reduce the need for using the technology or alter them to more adapted, conventional tools (Campbell et al. 2006). For example, a child with communication difficulties may use objects as a young toddler, transit to line drawings as a child, and use orthographic symbols in school, all using a SGD. A child with autism may need to use computer programs while learning to read and write. This child might learn to use these literacy abilities later for communication as well as for academic needs using traditional paper and pencil, a handheld computer, or a complex SGD. In one study, for example, orthographic and graphic symbols were taught to three girls with Rett syndrome using a computer equipped with a dedicated software program and switches as peripherals (Hetzroni et al. 2002). After the girls finished the learning process, the symbols became part of their communication used for both academic and communicative needs. They used the symbols to select preferred books to read, to select music, and to choose what food they wanted to eat. AT can be used directly for the child's needs as well as for the teacher. This interactive use of technology intensifies the importance of AT as a powerful tool in special education (Hetzroni and Schanin 2002; Kinsley and Langone 1995).

Some of the programs available for use with literacy include "speech recognition" and "text to speech." "Speech recognition" includes programs that can recognize speech, process it, and convert it to a written form. These programs can also

identify spoken commands and activate the computer without touch. The efficiency of one such program was investigated with children that have been identified as having learning disabilities (Reece and Cummings 1996). The purpose of the study was to investigate whether simulating text reading is advantageous for the children by enabling them to view the words unfold as they read the text aloud. The effectiveness of the program was compared with the traditional method of listening to a tape that had the same text stored in it. Results of this study revealed that while for typically developing children both methods were similar, the ability to observe the unfolding of the text resulted in significantly higher scores both in quality and in quantity for the children with learning disabilities.

While these programs became available in the past decade, they still remain difficult to use, as they require a "teaching" process in which the software requires the user's voice to be recognized by the computer, through acquisition of patterns of voice and intonation. The process involves reading a specific text aloud to the computer until recognition is complete. The need to read out loud a specific text may hinder the possibility of a child with learning disabilities from reading such a text effectively with no mistakes, thus reducing the chance of enjoying the program. A child with physical difficulties may find it difficult to maintain the reading abilities for such a long text. Making these programs more "user friendly" may assist in turning them into more effective and more frequently used technologies (MacArthur 2000). The use of voice command has recently been implemented in a similar manner into technologies such as iPhones that enable individuals with special needs to use various applications such as Internet access without the need to write the command (Breen 2009). Such technology can assist children with physical disabilities or visual impairments in operating their phones, accessing the Internet, and manipulating their environment using this type of technology.

Another use of AT relates to "text to speech," or "speech synthesis," which assists in enabling the computer in identifying text, converting it to speech, and reading it out loud to the user. This type of technology often uses digitized speech, a prereordered human voice separated to phonemes and reassembled using simple typing on a keyboard. This complex mechanism, seemingly simple these days, can be used for decoding word documents as well as text directly taken from the Internet, thus producing it as a vocal digitized output. This system can be used by people with visual and hearing impairments as well as people with communication disorders who wish to vocally express their written ideas (Schlosser et al. 1998; Schlosser and Blischak 2004; Van Balkom and Verhoeven 2010). In a study investigating the use of this technology by children with autism, using voice-output "text to speech" activated by a computer enhanced spelling abilities of the children after practice with the software. When the children used the speech output as feedback, they were able to better spell the words presented to them (Schlosser et al. 1998). This technology also assisted students with learning disabilities who were able to detect more syntax and spelling errors using "text to speech" than when using no assistance or even when using a human reader (Dresang 2008; Raskind and Higgins 1998).

The use of digitized reading can be implemented at the end of every letter, word, sentence or paragraph, or any combination. This tool can be utilized for reading,

text comprehension, and practice and for identifying spelling mistakes made while writing (Mills 2010). The computer "reads" the text, thus enabling the person to listen to the written text or, when needed, use it to express one's wishes aloud. Thus, although this technology was created to enable people with visual impairments and communication disorders decode a written text and voice it out, it has been found to be effective as a tool for literacy acquisition for individuals with learning disabilities or communication disorders, as a tool for literacy purposes, and as a compensatory tool for decoding text (MacArthur 2000; Raskind and Higgins 1998; Schlosser et al. 1998).

The use of "text to speech" has been used recently in developing AT programs for use as augmentative and as compensatory tools that have open and closed parameters. This technology can be used to scaffold learning to read and write and to assist children in decoding difficult words or complex text. While enabling students learning to read and write by converting written text to speech, thus assisting in reading acquisition and comprehension, the most unique feature of this type of program is the ability to use it for writing with symbols. The program has efficient environments that assist acquisition of reading and writing while using graphic and orthographic symbols. The symbols appear above or below the text and can be used for encoding or decoding text, as they can represent abstract as well as concrete ideas and messages. They enable children to use symbols to augment learning language, communication, and literacy, as well as a compensatory tool for conveying ideas using auditory and visual means (Parette et al. 2008). For example, "Writing with Symbols©," created by Widgit®, is a program that has joined a large body of technologies used to fulfill academic and communicative needs of children with complex limitations for literacy and communication purposes, thus enabling enhancement of both areas using orthographic and graphic symbols.

"Writing with Symbols©," a program developed for enhancing literacy, language, and communication skills, has a dynamic display and uses graphic and orthographic symbols for assisting in learning to read and write. The program was translated to several languages. One of the added advantages of this program and others that serve the same purpose is the ability to use it in a variety of ways, for translating orthographic to graphic symbols, while using it as a word or symbol processor, as well as for using this program for voicing the text out loud. This enables an explanation of a difficult word, making it possible to understand the text and verifying the reliability of a written text before finalizing it. As such, a child with learning disabilities or visual impairments can voice the text out loud and compare between the original intent and the actual output. A child can use it to clarify a word in order to prevent misunderstanding of a sentence or to select a graphic symbol when a word is missing in the vocabulary. This program can also be used for creating dynamic displays and communication boards to be used by children with communication difficulties. For example, a story board can be created for a child with autism, for planning, practicing, and simulating social situations using both graphic and orthographic symbols and voicing out the social stories as part of a school activity. A dynamic communication display can be created with or by a child with physical limitations, for expressing needs or participating in classroom discussions (Parette et al. 2008). However, most

of the practitioners use this program as a word and symbol processor and therefore do not enjoy the program to its full potential.

The problem of practitioners not realizing the full potential of available technologies was addressed in a study which investigated the ability to maximize the use of assistive technologies for enhancing literacy and communication skills by children with various communication difficulties in the school system (Hetzroni et al. 2009). The study examined if providing the school with an instructional battery on technology as well as on the specifics of the program would increase the understanding of its unique possibilities as well as on the adaptations that the features of the program can prevail for use with various kinds of students. Following the understanding of the program and its features, the study investigated if this complex program could increase early literacy skills as well as language and communication skills of children with various communication needs.

Six schools participated in the study: two schools for children with autism (elementary and high school), two schools for children with physical disabilities (preschool/kindergarten and cross-age elementary and high school), one school for children with cognitive limitations (cross-age elementary and high school), and one school for children with hearing impairments and other complex disabilities (cross-age elementary and high school). Children ranged in age from 3–5 years in the preschool/kindergarten to 14–18 years in high school. Cross-age elementary and high schools included children ranging in age from 6 to 18.

Eighty children from the six schools were tested at the beginning and at the end of the school year to detect language and communication gains as well as early literacy skills. The children's teachers were also asked about the progress of those children during the school year. Twenty-eight teachers were asked about the use of the program as a direct tool for teaching literacy as well as its use as a communication tool and the use of "Writing with Symbols©" and other computer programs used for communication and literacy learning in school. Results of the study demonstrated a significant increase in the children's abilities between the beginning and the end of the school year. The results were higher in syntax, vocabulary, morphology, and context; the most significant difference was in vocabulary gains. Literacy and communication gains were significant in schools receiving intensive training and less significant in schools receiving partial training. The most significant change in vocabulary acquisition was apparent in the kindergarten children, a result that can be explained also in light of the vocabulary burst expected from children in that age range. Teachers reported that following instruction they began to understand how to use the program for direct and indirect purposes, for preparing materials for the students, and for working on literacy and communication activities.

Summary

AT has supported literacy acquisition and comprehension, used as scaffolds and prostheses tools by individuals with communication difficulties. Some of the technologies were created for the general population, while others were created

specifically for use by individuals with special needs. Understanding the variability of the tools and the specifications as well as the understanding that such tools are available for use across various purposes can make AT visible, available, and effective for meeting the great myriad of distinct needs of individuals at different times and settings.

AT can assist from the very first stages of early literacy by learning to use a switch to choose a book to read, using a pointer to follow the text, and making comments and asking questions about the story throughout one's life in accordance with individual needs. Over the years, the selection process becomes evident as a powerful tool for manipulating the environment, participating in the discussion, and having the ability to converse through graphic and orthographic means. The use of technologies has empowered human beings to enhance abilities and achieve. Assistive technology has the power to enhance abilities, provide opportunities to achieve, and overcome barriers. Literacy is the key to success in present society. It holds knowledge that can enable the user to achieve and maintain competence from childhood to adulthood. Understanding the power of assistive technology, increasing knowledge in the field, and keeping informed on the technological innovations can act as a key to independence and success for those with communication and learning disabilities.

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