Assistive Technology
Outcomes and Benefits

Published by the Assistive Technology Industry Association (ATIA)

Volume 14

Spring 2020

Assistive Technology for Literacy

Anne M. Hayes
Focused Issue Editor

Anya S. Evmenova
Editor-in-Chief

Kate Herndon &
Carolyn P. Phillips
Associate Editors

ATiA Assistive Technology Industry Association

ISSN 1938-7261

Assistive Technology Outcomes and Benefits
Assistive Technology for Literacy
Volume 14, Spring 2020

Assistive Technology Outcomes and Benefits (ATOB) is a collaborative peer-reviewed publication of the Assistive Technology Industry Association (ATIA). Editing policies of this issue are based on the Publication Manual of the American Psychological Association (6th edition) and may be found online at www.atia.org/atob/editorialpolicy. The content does not reflect the position or policy of ATIA and no official endorsement should be inferred.

Editorial Board Members and Managing Editors

Peer Reviewers for ATOB Volume 14
Assistive Technology for Literacy

The Editorial Board would like to thank the peer reviewers who generously donated their time and talent to reviewing manuscripts for this Volume 14 of ATOB.

Melissa Ainsworth
Patricia Bath
Alicia Drelick
Jody Floyd
Cassie Frost
Lynn Gitlow
Siobhán Long
Donna McClure-Rogers
Virginia Morash-MacNeil
Laura Nichols
Jane Obrien
Martha Rust
Kindy Segovia
Bev Sharritt
Kelli Suding
Elisa Wern

Assistive Technology Outcomes and Benefits
Editorial Policy

Aim and Scope

Assistive Technology Outcomes and Benefits, published by the Assistive Technology Industry Association, is an open access, peer-reviewed journal that publishes articles specifically addressing the benefits and outcomes of assistive technology (AT) for Persons with Disabilities across the lifespan. The journal's purpose is to advance the AT industry by (a) fostering communication among stakeholders interested in the field of AT, including manufacturers, vendors, practitioners, policy makers, researchers, consumers with disabilities, and family members; (b) facilitating evidence-based demonstrations and case-based dialogue regarding effective AT devices and services; and (c) helping stakeholders advocate for effective AT devices and services.

Assistive Technology Outcomes and Benefits invites for consideration submissions of original papers, reports and manuscripts that address outcomes and benefits related to AT devices and services. These may include (a) findings of original scientific research, including group studies and single subject designs; (b) marketing research related to AT demographics or devices and services; (c) technical notes regarding AT product development findings; (d) qualitative studies, such as focus group and structured interview findings with consumers and their families regarding AT service delivery and associated outcomes and benefits; (e) project/program descriptions in which AT outcomes and benefits have been documented; (f) case-based reports on successful approaches to service delivery; and (g) consumer perspectives on AT devices and services.

Submission Categories

ATOB welcomes scholarly contributions. However, many stakeholders engaged in the field of AT do not have an academic background. ATOB offers a unique opportunity for these stakeholders to contribute their expertise and experience in the context of achieving successful outcomes and beneficial impacts. ATOB understands that many potential authors may lack experience in authoring papers for peer-reviewed journal publication. Therefore, the ATOB Editorial Board is pleased to offer assistance in preparing and refining relevant submissions.

Voices from the Field

Articles submitted under this category should come from professionals who are involved in some aspect of AT service delivery with persons having disabilities, or from family members and/or consumers with disabilities. Submissions may include case studies, project or program descriptions, approaches to service delivery, or consumer perspective pieces. All submissions should have a clear message and be written with enough detail to allow replication of results.

Voices from the Industry

Articles submitted under this category should come from professionals involved in developing and marketing specific AT devices and services. Case studies, design, marketing research, or project/program descriptions are appropriate for this category.

Voices from Academia

Articles submitted under this category should come from professionals conducting research or development in an academic setting. Submissions are likely to include applied/clinical research, case studies, and project/program descriptions.

Types of Articles

Within each of the voices categories, authors have some latitude regarding the type of manuscript submitted and content to be included. However, ATOB will only accept original material that has not been published elsewhere, and is not currently under review by other publishers. Additionally, all manuscripts should offer sufficient detail to allow for replication of the described work.

Applied/Clinical Research

This category includes original work presented with careful attention to experimental design, objective data analysis, and reference to the literature.

Case Studies

This category includes studies that involve only one or a few subjects or an informal protocol.

Design

This category includes descriptions of conceptual or physical design of new AT models, techniques, or devices.

Marketing Research

This category includes industry-based research related to specific AT devices and/or services, demographic reports, and identification of AT trends and future projections.

Project/Program Description

This category includes descriptions of grant projects, private foundation activities, institutes, and centers having specific goals and objectives related to AT outcomes and benefits.

Approaches to Service Delivery

This category includes descriptions of the application of assistive technology in any setting (educational, vocational, institutional, home-life) to improve quality of life for people with disabilities.

Consumer and Caregiver Perspectives

This category offers an opportunity for product end users, family members, and caregivers to share their experiences in achieving successful outcomes and benefits through the application or use of AT devices and services.

Mandatory Components of All Articles

Authors must include a section titled Outcomes and Benefits containing a discussion related to outcomes and benefits of the AT devices/services addressed in the article.

Authors must include a short description of the article's target audience, and indicate the article's relevance to that target audience. Authors may describe their work as it relates to more than one audience, and should specify the value that each group may derive from the work.

Publishing Guidelines

Each manuscript must reflect the style guidelines of the Publication Manual of the American Psychological Association (6th edition, 2009). Note: APA 7th edition (2019) will be used starting in Volume 15.

Manuscripts should be no more than 25 pages in length (double-spaced) including references but excluding tables and figures.

Due to the electronic format of the journal, all submissions should be submitted as email attachments in a **Microsoft® Word format.**

See the detailed Manuscript Preparation Guidelines for Authors for more information on formatting requirements and submission instructions.

For More Information

Please see ATOB's Editorial Policy at http://www.atia.org/at-resources/atob for more details regarding the submission and review process, ATOB's Copyright Policy, and ATOB's Publication Ethics and Malpractice Statement.

Assistive Technology Outcomes and Benefits
Assistive Technology for Literacy
Volume 14, Spring 2020

Table of Contents

Introduction to Volume 14 viii

Voices from Academia

Graphic Symbols: Improving or Impeding Comprehension of Communication Bill of Rights? 1

Text-to-Speech Technology: Enhancing Reading Comprehension for Students with Reading Difficulty 19

The Development of an Assistive Technology Toolkit for Early Literacy Instruction 36

Mastery of Assistive Technology in High School and Postsecondary Performance 52

Voices from the Industry

Driver Training Application for Individuals with Autism 77

Voices from the Field

The Evolving Landscape of Assistive Technology in K-12 Settings 94

Emergent Literacy for Students with Cortical Vision Impairment: Self-Directed Reading 111

Enhancing Structured Literacy™ Instruction with Educational Technology 129

Emergent Literacy Instruction for Students with Significant Disabilities in the Regular Classroom 135

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. viii-x
 ISSN 1938-7261
Available online: www.atia.org/atob

Introduction to Volume 14

Anne M. Hayes, M.Ed.

Inclusive Development Partners (IDP)

Corresponding Author
Anne M. Hayes
Inclusive Development Partners
4700 Mueller Blvd.
Austin, TX 78723
Phone: (512) 391-6541
Email: anne@inclusivedevpartners.com

Welcome to Volume 14 of Assistive Technology Outcomes and Benefits (ATOB). The theme of this issue is "Assistive Technology for Literacy" which is an ever-growing topic of interest. To address this interest, ATOB editors have brought together a series of thought-provoking articles that highlight recent advancements in the field of AT and technologies. These articles can inform policies and practice both at the national and local levels. As the mother of a child who uses AT to express his literacy skills, I am able to witness how these advances can also improve the lives of individual students. The collection of articles included within Volume 14 of ATOB offers different perspectives on how AT can be used to improve literacy skills for students with various types of disabilities from early childhood to higher education.

The volume begins with an article representing Voices from Academia with Sofia Benson-Goldberg and Karen Erickson of University of North Carolina who explore the extent to which adults understand the graphic symbols paired with the Communication Bill of Rights. The study shows that the graphic symbols provided little support to participants to comprehend the text. Results are used to discuss implications for pairing graphic symbols with text with persons with IDD. The volume then leads into an article by Jennifer Keelor, Nancy Creaghead, Noah Silbert, and Tzipi Horowitz-Kraus who highlight key findings of a recent study that investigates the impact of text-to-speech (TTS) on reading comprehension for students with reading difficulty. The study shows that reading comprehension was significantly higher for students using TTS, signifying that TTS is an effective reading support tool for many students.

Starting at the preschool level, authors Ruby Natale, Christina Sudduth, Monica Dowling, Sarah Messiah, Christina Nunez and Michelle Schladant explore how the use of AT can improve early literacy outcomes. The article provides information about how a training program called Step Up AT to Promote Early Literacy (Step Up AT) for teachers and parents of children with disabilities from ages 3 to 5 promotes early literacy development skills. Using a multi-pronged approach through online learning modules, access to AT tools, and in-person coaching for teachers and caregivers, this toolkit improved literacy skills for children with a variety of disabilities from diverse language and cultural backgrounds in South Florida. Finally, within this section of Voices from Academia, Ben Satterfield's article on Mastery of Assistive Technology in High School and Postsecondary Performance summarizes a survey of 47 students with high-incidence disabilities in the university system in Georgia who received AT supports. Anecdotal comments reveal that students may be more successful in college if they are comfortable using AT before entering higher education

Volume 14 also includes one article representing Voices from the Industry by Miriam Monahan, Johnell Brooks, Julia Seeanner, Casey Jenkins, and Jay Monahan that applied usability principles and a subject matter expert to improve the literacy of an AT application designed to address driving literacy and visual search skills for individuals with autism spectrum disorder.

Volume 14 then concludes with Voices from the Field starting with the perspective of Denise DeCoste and Gayl Bowser. This article on the evolving landscape of assistive technologies in K-12 settings demonstrates how technologies and the roles of AT providers have shifted over the last 30 years. This article discusses various elements of successful implementation of AT in the classroom, including the intersection between AT and Universal Design for Learning (UDL). Deanna Wagner and Gretchen Hanser then explore early childhood and emergent literacy for students with cortical vision impairment, and opportunities for self-directed reading and the use of PowerPoint to make books that are customized to meet students' vision needs. Within this section, Sharon LePage Plante also reviewed how a technology program, Structured Literacy™, provides direct and explicit instruction for students to decode words. This approach demonstrates how AT can be an effective tool for engagement with documented gains in students' work. At the secondary school level, Lauren Tucker's article, Adapted Text Benefits for Teachers and Students: A Retroactive Case Study, explores the utilization of pre-created audio supported adapted text paired with instructional practices in a self-contained English classroom. The study reports a positive influence on students within a self-contained English classroom as well as increased student engagement and motivation with the new learning materials. Volume 14 then concludes with Erin Sheldon and Karen Erickson who explore comprehensive emergent literacy instruction and the barriers faced by students with severe disabilities and complex communication needs (CCN) when accessing general education curriculum. This article effectively demonstrates the need to educate students with severe disabilities and CCN in inclusive settings coupled with evidence-based comprehensive emergent literacy interventions.

These articles show the powerful impact of technology for students with diverse categories of disabilities, from early childhood to higher education. Each article highlights different ways AT is being used to increase motivation and improve learning outcomes. Please review and reflect upon these articles and share them broadly to help us make the world a more accessible place.

Declarations

This content is solely the responsibility of the authors and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author of this paper.

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 1-18
 ISSN 1938-7261
Available online: www.atia.org/atob

Graphic Symbols: Improving or Impeding Comprehension of Communication Bill of Rights?

Sofia Benson-Goldberg, M.S., CCC-SLP, Karen Erickson, PhD

Center for Literacy and Disability Studies
University of North Carolina at Chapel Hill

Corresponding Author
Sofia Benson-Goldberg
University of North Carolina at Chapel Hill
CB #7335 UNC-CH
Chapel Hill, NC 27599-7335
Phone: (919) 966-8566
Fax: (919) 843-3250
E-mail: sofia_bensongoldberg@med.unc.edu

Abstract

It is widely assumed that pairing graphic symbols with text will support text comprehension. This has led to the practice of coupling text with graphic symbols to make it more accessible and understandable. Unfortunately, there is little empirical evidence to support this assumption or practice. The current study investigated the use of single graphic symbols to convey the meaning of the 15 statements that comprise the Communication Bill of Rights. Fifty-two speech-language pathology graduate students that were enrolled in a graduate-level augmentative and alternative communication course participated. They were asked to determine the right conveyed by each of 15 graphic symbols in an open-ended task, and then to match the symbols to the corresponding statements in a multiple-choice task. Participants had limited success with both tasks regardless of year in school or previous experience with graphic symbols. Implications for the use of graphic symbols to support text comprehension are discussed.

Keywords: graphic symbols, assistive technology, literacy, symbol supported text.

Introduction

Decades of research have demonstrated that people with severe disabilities demonstrate significant difficulty learning to read (e.g., Conners, 2003; Erickson & Geist, 2016). School-aged students with intellectual and developmental disabilities (IDD) have low levels of reading achievement and take longer to make gains in reading than their peers without disabilities (Allor et al., 2014). As adults, individuals with IDD continue to struggle to read words and comprehend text (Jones et al., 2006). As a result, individuals with IDD often find it difficult if not impossible to access text (Hurtado et al., 2014). To address this challenge, the recommendation is often made to add pictures, pictograms, or graphic symbols to the text (e.g., Nomura et al., 2010; Office for Disability Issues, 2018). Individual pictures, pictograms, or graphic symbols can be selected to represent the meaning of an entire sentence, key ideas in a sentence, or all of the meaning and grammatical information in a sentence (Poncelas & Murphy, 2007). Unfortunately, there is little empirical support for any of these uses of pictures, pictograms, or graphic symbols to support text comprehension (Erickson et al., 2010; Hurtado et al., 2014). The purpose of this study was to investigate the use of individual graphic symbols to represent the meaning of each statement from the Communication Bill of Rights (Brady et al., 2016).

Graphic Symbols

There are many types of graphic symbols. Some are simple line drawings, some are abstract shapes, and others are colorful and detailed. Graphic symbols that clearly represent a referent are said to be transparent. Graphic symbols that are easily learned but not transparent are labeled translucent, and those that have no visual relationship to a referent are abstract or opaque (Beukelman & Mirenda, 2013). Graphic symbols that represent concepts (e.g., more, some, want) rather than objects or actions and those that represent grammatical function words (e.g., is, are, can) are necessarily abstract or opaque because those words are not easily represented by a picture.

Graphic symbols for expressive communication. For several decades, graphic symbols have been used extensively to support expressive communication for individuals with complex communication needs (Beukelman & Mirenda, 2013). In this context, graphic symbols can support individuals with IDD in augmenting or replacing their speech to communicate more effectively with others (Snell et al., 2010). When graphic symbols are used with individuals with complex communication needs to support expressive communication, the meaning of the symbols are generally taught directly by pairing them with the assigned referent (Isaacson & Lloyd, 2013) or indirectly through extensive demonstrations of their use (O'Neill et al., 2018). In either case, it is understood that individuals must learn the meaning of the symbols to use them effectively in expressive communication.

Graphic symbols for text access. Similarly, graphic symbols have been used in the context of literacy for many decades (e.g., Samuels, 1967); however, their use in the context of literacy has not been quite as successful (Erickson et al., 2010). For example, children (Singh & Solman, 1990) and adults (Pufpaff et al., 2000) with IDD can learn to read words paired with symbols, but it takes longer to learn to read a printed word when it is taught paired with a picture. Furthermore, the addition of graphic symbols to text does little to support comprehension (e.g., Hurtado et al., 2014; Jones et al., 2006 Poncelas & Murphy, 2007). Nonetheless, guidelines regarding text accessibility continue to include recommendations for the inclusion of graphic symbols (e.g., Department of Health, 2010; Office for Disability Issues, 2018), and various stakeholders respond positively and enthusiastically to texts that are supported with graphic symbols (Parson & Sherwood, 2015).

The Current Investigation

The current investigation was prompted by a flurry of social media posts regarding an informational document called the Communication Bill of Rights (Brady et al., 2016), its accessibility, and the assumption that adding graphic symbols would make the document more accessible to individuals with IDD who have complex communication needs. Subsequent to that flurry of activity, numerous individuals and agencies began creating versions of the Communication Bill of Rights that had graphic symbols inserted (see: Lovatt, 2017). We were left with the question, *Do the graphic symbols support understanding of the Communication Bill of Rights?*

About the Communication Bill of Rights

The Communication Bill of Rights was developed by the National Joint Committee for the Communication Needs of People with Severe Disabilities (NJC), which is an interdisciplinary group founded to advocate for the communication needs of people with severe disabilities (http://www.asha.org/njc). An original Communication Bill of Rights was published in 1992 (National Joint Committee for the Communication Needs of Persons with Severe Disabilities) and a revised Communication Bill of Rights was published in 2016 (Brady et al., 2016).

Although the Communication Bill of Rights is designed to be a list of rights that professionals pledge to support when working to support the communication of individuals with IDD, there is also an interest in making sure that individuals with IDD understand their rights. As a result, the Communication Bill of Rights has been reprinted such that each right is represented by and paired with a graphic symbol (see: Lovatt, 2017). Presumably, this has been done to allow those who cannot read to understand each right, while improving understanding for others who can decode the words but not understand the meaning (Freyhoff et al., 1998).

The purpose of the current study was to understand whether the symbols chosen to represent each of the fifteen rights are decodable. Specifically, the study aimed to address two primary questions: (1) How well do literate adults who are familiar with graphic symbols and the purpose of the Communication Bill of Rights determine the content of each right based solely on the graphic symbol? and (2) How accurately can the same adults match each right with the graphic symbol that was selected to represent it?

Target Audience and Relevance

The audience for this paper includes special educators, speech-language pathologists, occupational therapists, assistive technology specialists and parents who find themselves tasked with supporting students with IDD in accessing academic curriculum – including literacy instruction – or who find themselves advocating for increased access to text for individuals with IDD. This information may also be of interest to administrators and curriculum coordinators who make purchasing decisions that impact the text with which students interact with in the classroom.

Outcomes and Benefits

Despite Federal legislation mandating increased access to curriculum and standards-based instruction, students with IDD continue to have reduced opportunities to engage in literacy and print-based instruction in schools (Ruppar, 2015). The results of this study have the potential to impact the AT supports provided to students, so that they might enjoy increased access to text and increased success in understanding the text they do access.

Method

This study was approved by the Institutional Review Board of the university where the authors are employed.

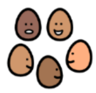
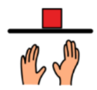
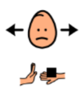
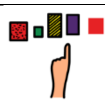
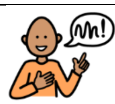
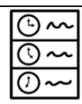
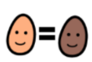
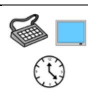
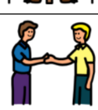
Participant Recruitment

Graduate students in speech and language pathology who were enrolled in a semester-long course on augmentative and alternative communication were invited to participate in the study during class time. All first- and second-year master's students in speech and language pathology were enrolled in the course and all 52 consented to participate. As is expected in the field of speech-language pathology, most of the students identified as female (92.3%). The remaining students identified as male (5.8%) or other (1.9%). The students had a mean age of 25 but ranged in age from 21 to 33 years old. The students were evenly distributed between first (50%) and second year (48.1%) master's students, with one Ph.D. student (1.9%). Most students (76.9%) indicated they had prior experience and exposure to Picture Communication Symbols© from Mayer-Johnson (2006); however, for nearly all students, this course was their first focused on augmentative and alternative communication (98.1%). There were differences by year in the program in regard to exposure to Picture Communication Symbols © (Mayer-Johnson, 2006), with students in their second year being statistically significantly more likely to indicate that they had experience with them (X2 (1) = 11.79, p = 0.00). As such, differences between cohorts were investigated.

Selecting an Example Communication Bill of Rights

The process of selecting which graphic-symbol-supported Communication Bill of Rights to use in the current study began with an internet search to preview those that have been posted. After reviewing several dozen, the pool was narrowed down to those that retained the original wording of the Communication Bill of Rights. From that much smaller pool, we sought a version that had a single symbol representing each right. Our desire was to focus on a version that used symbols in a functional way rather than representing keyword or supporting word-by-word symbol reading (Poncelas & Murphy, 2007). That is, we wanted a version with a single symbol that was intended to represent the whole sentence, or, in the case of this study, the whole right. We could have selected a version with a keyword approach that used symbols to represent all the key ideas in each right, or we could have selected or created a version that supported reading by pairing a symbol with each key idea and grammatical marker. In the end, we selected the AGOSCI Inc. (Lovatt, 2017) symbol-supported version of the Communication Bill of Rights (Brady et. al., 2016). Table 1, Picture Communication Symbol Representing Corresponding Right, displays the Picture Communication Symbols© from Mayer-Johnson (2006) and the rights they represent per the AGOSCI document.

Table 1: Picture Communication Symbol Representing Corresponding Right

Number	PCS Symbol	The right to…
1		Interact socially, maintain social closeness, and build relationships
2		Request desired objects, actions, events, and people
3		Refuse or reject undesired objects, actions, events, or choices
4		Express personal preferences and feelings
5		Make choices from meaningful alternatives
6		Make comments and share opinions
7		Ask for and give information, including information about changes in routine and environment
8		Be informed about people and events in one's life
9		Access interventions and supports that improve communication
10		Have communication acts acknowledged and responded to even when the desired outcome cannot be realized
11		Access to functioning AAC and other AT services and devices at all times
12		Access environmental contexts, interactions, and opportunities that promote participation as full communication partners, with other people, including peers
13		Be treated with dignity and addressed with respect and courtesy

Number	PCS Symbol	The right to…
14		Be addressed directly and not be spoken for or talked about in the third person while present
15		Have clear, meaningful, and culturally and linguistically appropriate communications

Source: The Picture Communication Symbols ©1981-2015 by Mayer-Johnson LLC. All Rights Reserved Worldwide. Used with permission.
Source: The Communication Bill of Rights (Brady et al., 2016). Reprinted with permission.

Instrument

Two tasks were created for all participants to complete. The first was open-ended and the second was multiple-choice. Two were constructed because the type of task impacts results when participants are asked to demonstrate comprehension of symbols (see Wolff & Wogalter, 1998). While an open-ended format is often recommended, responses to open-ended questions can be vague (Lesch & McDevitt, 2002). Multiple-choice clarifies responses, but it also narrows the range of response options. As such, in the current study, both an open-ended and a multiple-choice format were used to ask participants what right each symbol represented.

To construct the two tasks, original versions of the graphic symbols that appeared in the AGOSCI Inc. (2017) symbol-supported version of the Communication Bill of Rights (Brady et. al., 2016) were secured from Boardmaker Online© and uploaded to Qualitrics. In both tasks, the symbols were presented in 3” x 3” size. In the open-ended task, each symbol was presented in random order with a text-entry box. A directions screen was inserted that explained that participants would see symbols representing the Communication Bill of Rights one at a time, and they were to use the space provided to write the right the symbol represented. “The right to” was written beneath each symbol and above the text entry box in order to support responses (see Figure 1, Open-ended survey question format, for example).

The second task was also constructed to present the graphic symbols in random order, but each was accompanied by a drop-down menu with all 15 rights. The directions informed participants that they should select the right they believed was represented by each symbol. The drop-down menu included all 15 rights for each graphic symbol to prevent participants from using process of elimination to make decisions.

The two tasks were combined into a single Qualtrics survey. The open-ended task always appeared first, followed by the multiple-choice task, and then a section requesting relevant demographic and prior-usage information including date of birth, gender, year in school, prior AAC course experience, and prior experience with PCS symbols. Participating students had as much time as they needed to complete the survey.

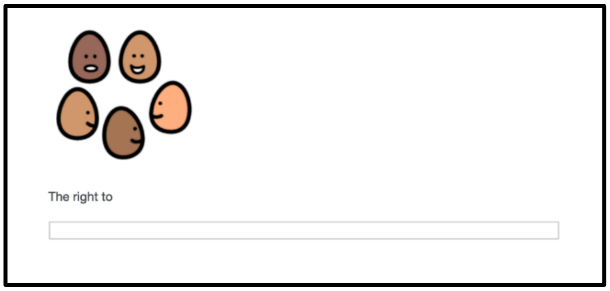


Figure 1: Open-ended survey question format.

Source: The Picture Communication Symbols ©1981-2015 by Mayer-Johnson LLC. All Rights Reserved Worldwide. Used with permission.

Procedure

Participants were recruited during a regularly scheduled meeting of the graduate course in augmentative and alternative communication that they were completing. They were given a brief overview of the study and informed about the purpose of the investigation (i.e., to further our understanding of how graphic symbols support comprehension). Students were informed that their participation was voluntary and that their individual responses would be kept confidential. Subsequently, anonymous links to the Qualtrics survey were distributed to the entire class via email. Once opened, the survey prompted participants to indicate that they consented to participate in the study. All participating students independently accessed the survey via their own personal computers by using the anonymous link sent to their academic email accounts.

Analysis

Recommendations for scoring open-ended questions about symbol meaning overwhelmingly favor a purely dichotomous procedure (Lesch & McDevitt, 2002; Wolff & Wogalter, 1998). However, this risks reducing or limiting the richness of the analysis (Lesch & McDevitt, 2002). With this in mind, a modified dichotomous scoring procedure was created. Rather than score the participants' responses as completely right (1) or completely wrong (0), the rights were broken down into meaningful components. Some rights had only two or three meaningful components while others had as many as six (see Table 2, Meaningful Component Breakdown by Right for a breakdown of the meaningful components in each right). This scoring paradigm involved giving credit for partially accurate responses, including one-word responses that reflected a major, meaningful component of the right, without losing the richness and complexity that each right represents. To ensure the reliability of the scoring, the first author scored all responses and the second author re-scored 20% of the participants' responses to all 15 rights. Overall, agreement (i.e., number of agreements divided by the total number of possible points) was 95%, with modest variations by participant (92-98%) and by right (87-100%). Disagreements were discussed with a final decision determined by consensus.

Table 2: Meaningful Component Breakdown by Right

	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6
1	interact socially	maintain social closeness	and build relationships			
2	request	desired objects	actions	events	and people	

	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6
3	refuse or reject	undesired objects	actions	events	or choices	
4	express	personal preferences	and feelings			
5	make choices	from meaningful alternatives				
6	make comments	and share opinions				
7	ask for	and give information	including about changes in routine	and environment		
8	be informed	about people	and events	in one's life		
9	to access intervention	and supports	that improve communication			
10	have communication acts acknowledged	and responded to	even when the desired outcome cannot be realized			
11	have access to functioning AAC	and other AT services and devices	at all times			
12	access environmental contexts	interactions	and opportunities	promote participation as full communication partners	with other people,	including peers
13	be treated with dignity	addressed with respect	and courtesy			
14	be addressed directly	and not be spoken for	or talked about in the third person and share opinions while present			
15	have clear	meaningful	and culturally and linguistically appropriate communication			

The multiple-choice questions were scored dichotomously, and the participants' raw scores were used for item analysis. This approach to item analysis allowed each item to be given a difficulty and discrimination index score, and it allowed for response patterns to be investigated. In this context, difficulty referred to the probability that participants correctly identified the right that matched an individual graphic symbol. Lower difficulty scores indicate that items were more difficult for a group of participants. See Table 3, Difficulty Range and Interpretation, for item difficulty ranges and interpretations.

Table 3: Difficulty Range and Interpretation

Range	Interpretation
0.0-0.3	Extremely difficult
0.3-0.5	Very difficult
0.5-0.7	Moderately difficult
0.7-0.9	Moderately easy
0.9-1.1	Very easy

Item discrimination refers to the ability of an individual item to differentiate among participants' overall performance. That is, when an item has a lower discrimination score, then participants who are good at identifying the rights that are represented by symbols are more likely to respond correctly to that item, whereas those who are poor at identifying the right that is represented by a symbol are more likely to get that item wrong. Discrimination is considered "good" if the index is above .30; "fair" if between .10 and .30 and "poor" if below .10 (Crocker & Algina, 1986).

Results

The Open-Ended Task

Participant responses to the open-ended task were analyzed to determine the number of major concepts represented for each right and the number of total words participants used to describe the right represented by each graphic symbol.

Content. Descriptive statistics regarding the number of major concepts represented were calculated for the group and for each right. Overall, most responses (58.8%) did not represent any of the meaningful components. The responses that did include a meaningful component only included one (31%) or two (10.1%) components. Frequency counts for the percent of concepts represented by the whole group across all rights are presented in Table 4, *Concepts Represented Across All Responses.*

Table 4: Concepts Represented Across All Responses

Concepts Represented	Frequency	Cumulative Responses
0%	459	58.85%
15-25%	76	68.59%
30-50%	184	92.18%
60-75%	59	99.74%
100%	2	100%

Each participant received a total score for each right. This was done by dividing the number of components represented by the total possible components. Overall, group performance was extremely low (M = 16.83%, 0-54.5%). Descriptive statistics for the group, as well as by year in school, are presented in Table 5, Total Score by Group and Year in School, along with results from paired-samples t-tests. While overall performance was low, significant differences between years in school were found for responses for two rights. First-year student responses were more likely to represent one component of the twelfth right, and one to two components of the ninth right.

Table 5: Total Score by Group and Year in School

Right	Group Mean	Year 1 Average	Year 2 Average	*p*-value
1	19.2%	19.2%	18.7%	1.00
2	8.8%	8.5%	9.6%	0.802
3	18.5%	20.0%	16.8%	0.356
4	54.5%	52.6%	53.3%	0.417
5	48.1%	46.2%	50.0%	0.327
6	20.2%	21.1%	20.%	1.00

Right	Group Mean	Year 1 Average	Year 2 Average	*p*-value
7	15.4%	13.5%	18.0%	0.554
8	0.0%	0.0%	0.0%	
9	25.6%	33.3%	17.3%	0.005*
10	0.6%	0.0%	1.3%	0.327
11	35.3%	33.3%	37.3%	0.502
12	2.6%	4.5%	0.7%	0.011*
13	0.0%	0.0%	0.0%	
14	3.2%	3.2%	2.7%	0.664
15	0.6%	0.6%	1.3%	0.327

Word count. Descriptive statistics regarding the number of words participants typed in response to each symbol are presented in Table 6, Word Count by Right. More than half of the responses included only one to two words (56.54%), with one- to three-word responses constituting 75% of all responses. The Communication Bill of Rights (Brady et. al., 2016) averages 10 words per right (5-18).

Table 6: Word Count by Right

Right	0-2 Words Used	Minimum	Maximum	Mean
1	38.5%	1	12	3.38
2	63.5%	1	5	2.29
3	80.8%	1	5	1.88
4	61.5%	1	9	2.63
5	78.8%	1	7	1.79
6	50%	1	6	2.38
7	46.2%	0	10	3.19
8	50%	1	11	3.37
9	42.3%	0	11	3.29
10	67.3%	1	7	2.12
11	50%	1	15	3.52
12	57.7%	1	12	2.88
13	61.5%	1	5	2.19
14	46.2%	0	7	2.67
15	53.8%	1	8	3.02
Mean	56.54%	0.73	8.67	2.71

Multiple Choice

Descriptive statistics in regard to responses to all 15 symbols are shown in Table 7, Multiple Choice Results. The symbols with high percentages of correct responses were those that referred to the right to refuse (92%), express feelings (85%), make requests (83%), and to make choices (81%).

The most poorly comprehended symbols referred to the right to be informed about people and events in one's life (0%); to have communication acts acknowledged and responded to even when the desired outcome cannot be realized (7%), and to be treated with dignity and addressed with respect and courtesy (15%). Paired-samples t-tests indicated no differences between participants performance based on year in school. Overall participants correctly matched symbols to text 48.7% of the time.

Table 7: Multiple Choice Results

Right	Participants Correct	First Years Correct	Second Years Correct	*p*-value
1	61.5%	53.8%	68%	0.340
2	82.7%	84.6%	80%	0.295
3	92.3%	96.2%	88%	0.720
4	84.6%	80.7%	88%	0.377
5	80.8%	80.7%	84%	0.295
6	42.3%	46.1%	40%	0.639
7	48.1%	53.8%	40%	0.755
8	0%	0%	0%	
9	36.5%	42.3%	32%	0.694
10	7.7%	3.8%	12%	0.720
11	71.2%	76.9%	68%	0.377
12	11.5%	7.7%	16%	0.540
13	15.4%	7.7%	24%	0.074
14	44.2%	46.2%	40%	0.877
15	51.3%	50%	52%	0.562

An item-analysis was completed to arrive at a difficulty and discrimination score for each symbol (see Table 8, Item Analysis Results). The majority of the items were moderately, very, or extremely difficult for the participants (M = 67%). The remaining items received difficulty indexes that are interpreted as moderately easy (27%), with only one item receiving a very easy difficulty index score. The discriminating abilities of the items were predominately fair (60%). Two items had good discrimination, and three had poor discrimination. One item did not receive a discrimination score as no participants correctly identified the right associated with that symbol.

Table 8: Item Analysis Results

Right	Difficulty	Interpretation	Discrimination	Interpretation
1	0.6154	Moderately Difficult	0.0894	Poor
2	0.8269	Moderately Easy	0.0675	Poor
3	0.9231	Very Easy	0.2879	Fair
4	0.8462	Moderately Easy	0.3770	Good
5	0.8077	Moderately Easy	0.2996	Fair
6	0.4231	Very Difficult	0.2086	Fair
7	0.4808	Very Difficult	0.1659	Fair
8	0	Extremely Difficult		
9	0.3462	Very Difficult	0.2785	Fair
10	0.0769	Extremely Difficult	0.1122	Fair
11	0.7115	Moderately Easy	0.1246	Fair
12	0.1154	Extremely Difficult	0.0335	Poor
13	0.1538	Extremely Difficult	0.1591	Fair
14	0.4423	Very Difficult	0.1798	Fair
15	0.4808	Very Difficult	0.3085	Good

Discussion

The results of this investigation provide evidence that graphic symbols, in this case, the Picture Communication Symbols© (Mayer-Johnson, 2006), provide little support for comprehending the text of the Communication Bill of Rights (Brady et al., 2016). Regardless of year in school or previous symbol exposure, the participants demonstrated little success in either providing the content of each right when confronted with the symbol or attempting to match the symbol to the correct right. Specifically, in the open-ended condition, the participants failed to write anything related to the right over half of the time (58.8%), while in the matching condition they were correct less than half of the time (48.9%). These results suggest that the graphic symbols were not effective at supporting the participants' understanding of the Communication Bill of Rights (Brady et al., 2016).

In addressing our first question, we found that literate adults who were familiar with the purpose of the Communication Bill of Rights and with graphic symbols were unable to determine the content of each right based solely on the graphic symbol. When participants' responses included a component of the target right (41.2% of responses), an overwhelming percentage of those responses (92.18%) included 50% or less of the entire content of the right. That is, most of the time, the participants were unable to extract the meaning the symbol was intended to represent. The two correct responses (0.3% of all responses) were provided for the sixth right, The right to make comments and share opinions. It should be noted that this right was considered to only have two major components (1) to make comments and (2) share opinions, increasing the likelihood that a participant would encode the entire meaning of the text from a single graphic symbol.

An unexpected finding when examining the open-ended responses was the participant use of single-, two- and three-word phrases. As literate adults pursuing advanced degrees, it was assumed that the participants had previous experience with and exposure to the writing style of the Communication Bill of Rights (Brady et al., 2016). That is, we had anticipated that the participants would understand that rights tend to be statements that often have complex structure and syntax. When just accounting for the number of words, the Communication Bill of Rights (Brady et al., 2016) averages ten words per right, with a minimum of five and a maximum of eighteen words. Regardless of the length of each individual right, the individual graphic symbols were insufficient to elicit responses equal in length to the target.

Not only did the single symbols only elicit very brief responses in regard to length, but they also elicited very few main concepts. That is, for the open-ended responses that did pertain to the target right, a majority only represented one major concept (75.4%) with the remaining correct responses only representing two concepts (24.6%). Overall, this suggests that even for highly-literate adults, graphic symbols convey limited conceptual information. While not directly assessed, it appears that previous experience and performance with reading and writing texts like the Communication Bill of Rights were insufficient to overcome this. That is, these highly literate adults did not employ their background knowledge when responding but rather responded solely to the graphic image as a symbol representing a single, isolated meaning.

In addressing our second question, we found that the same adults demonstrated difficulty matching each graphic symbol to the appropriate right. As matching symbols is an easier task, it is not surprising that the participants were able to be highly successful on an isolated set of symbols (greater than 80%

accuracy for rights 2-5). However, taken as a whole the reduction in production burden did not appear to facilitate increased correct responses. Rather, participants were correct less than 50% of the time.

In order to measure how difficult the matching condition was, an item analysis was conducted. The results demonstrate that most of the items (67%) fell within the moderately to extremely difficult category. Only one item was determined to be extremely easy. Considering that the recommendation to pair graphic symbols with texts is based on the theory that graphic symbols make text comprehension easier, we would anticipate that item analyses would indicate far more items in the moderately to very easy category.

The item analysis also provides an index of item discrimination. Discrimination scores represent how likely it is that participants who performed well overall on a measure also performed well on a given item. If graphic symbols were helpful in aiding comprehension, it would be important to see that respondents who did well on individual items also did well on the overall measure. That is, good overall graphic symbol decoders should have done well on individual items. The majority of the discrimination scores are in the fair range, likely because of the overwhelmingly poor participant performance. This means any one symbol is equally as predictive of the participant's poor performance as the next symbol.

One argument for pairing graphic symbols with text is that it makes it easier for persons with IDD to extract meaning from text that they might not otherwise be able to read or understand (Sutherland & Isherwood, 2016). However, research has shown that consultants trained to support persons with IDD have difficulty understanding the meanings of graphic symbols (Strydom et al., 2001). The participants in the current study also had difficulty interpreting the meaning of these symbols. If adults who are likely to support persons with IDD in learning to use symbols to extract meaning find the task difficult, they are unlikely to be successful in their efforts to teach others to do so.

Limitations

This study is limited with respect to its sample composition and size, as well as the narrow focus on the single symbols paired with the Communication Bill of Rights (Brady et al., 2016). Sample composition and size were constrained by the graduate students enrolled in the augmentative and alternative communication course targeted for recruitment. Recruiting more pre-service and working professionals from a variety of disciplines (i.e., teachers, occupational therapists) who work with individuals with IDD would increase the external validity of this study, and the transferability of results to the wider population of adults who work with individuals with IDD.

Another limitation was the conscious decision to focus solely on the single symbols commonly paired with the Communication Bill of Rights (Brady et al., 2016). It is possible that participants would have been more successful in determining the critical elements of each right in the open-ended task if they had access to symbols representing each of the words or each of the key words in each right. Similarly, it is logical that more graphic symbols would have allowed participants to use a range of problem-solving skills to match a string of symbols to the appropriate right. However, our extensive search of efforts to make the Communication Bill of Rights accessible consistently revealed solutions with single symbols representing each right rather than a string of symbols to match each word or keyword. As such, we felt it was important to investigate the supportiveness of the single symbols.

Implications and Future Research

The results of this study demonstrate that the graphic symbols paired with the Communication Bill of Rights (Brady et al., 2016) did not support participants' text comprehension, regardless of task, year in school, or previous exposure to graphic symbols. Furthermore, even for these highly literate adults, the task of matching symbols to text was difficult at best. The findings presented in this study do not support the pairing of graphic symbols with text, as it does not facilitate text comprehension. Rather, it represents a challenging task that even those with high levels of literacy and experience with graphic symbols are unable to complete successfully.

As we look towards improving the literacy outcomes for people with IDD, alternatives to symbolated text need to be investigated. For example, recommendations nearly universally support the use of shortened and simplified text (e.g. Freyhoff et al., 1998; Nomura et al., 2010). Simplifying the text in this way would be required to take advantage of text-to-speech and other common means of making text more accessible to individuals with a variety of disabilities, as individuals with IDD struggle with comprehension, whether listening to or reading text (Douglas et al., 2009). Assistive technologies that automatically simplify text should be investigated both by academics and manufacturers. These technologies might be paired with comprehensive literacy instruction to support people with IDD in increasing their literacy skills: both decoding and comprehension. Pairing instruction with assistive technologies that actually improve access to text and text-based interactions would have the benefit of increasing skills for people with IDD beyond teaching them the meaning of an individual text. Only by improving decoding, fluency, and comprehension might we support people with IDD in becoming independent readers with wide, independent access to text.

Conclusions

As policymakers continue to implore schools and school teams to improve the instruction and assistive technology supports provided to students with IDD, it is important to consider the role of graphic symbols as an assistive technology support. While there is ample evidence that graphic symbols are helpful in the context of expressive communication for individuals with complex communication needs (Beukelman & Mirenda, 2013) there continues to be little evidence that they are a useful support for text comprehension (Erickson et al., 2010). Rather than continuing with an approach that has consistently proven not to achieve its intended purpose, the field of assistive technology should direct efforts to identifying and developing technologies that improve direct access to and comprehension of text. This will have a direct impact on the text-based learning opportunities we might provide people with IDD, ultimately improving literacy outcomes in a way that pairing graphic symbols with text has failed to provide.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author(s) of this paper.

References

Allor, J. H., Mathes, P. G., Roberts, J. K., Cheatham, J. P., & Al Otaiba, S. (2014). Is scientifically based reading instruction effective for students with below-average IQs? *Exceptional Children, 80*, 287-306. doi: 10.1177/0014402914522208

Beukelman, D. R., & Mirenda, P. (2013). *Augmentative & alternative communication: Supporting children and adults with complex communication needs* (4th ed.). Baltimore: Paul H. Brooks.

Brady, N. C., Bruce, S., Goldman, A., Erickson, K., Mineo, B., Ogletree, B. T., …Wilkinson, K. (2016). Communication services and supports for individuals with severe disabilities: Guidance for assessment and intervention. *American Journal on Intellectual and Developmental Disabilities, 121*(2), 121-138,165-168. doi:10.1352/1944-7558-121.2.121

Conners, F. A. (2003). Reading skills and cognitive abilities of individuals with mental retardation. In Abbeduto, L. (Ed.). *International review of research in mental retardation* (Vol. 27, pp. 191-229). Academic Press.

Crocker, L. M., & Algina, J. (1986). *Introduction to classical and modern test theory.* New York: Holt, Rinehart and Winston.

Department of Health (2010). Making written information easier to understand for people with learning disabilities. London, UK: Department of Health. Retrieved from https://www.gov.uk/government/publications/making-written-information-easier-to-understand-for-people-with-learning-disabilities-guidance-for-people-who-commission-or-produce-easy-read-information-revised-edition-2010

Douglas, K. H., Ayres, K. M., Langone, J., Bell, V., & Meade, C. (2009). Expanding literacy for learners with intellectual disabilities: The role of supported eText. *Journal of Special Education Technology, 24*(3), 35-44. doi:10.1177/016264340902400304

Erickson, K., & Geist, L. A. (2016). The profiles of students with significant cognitive disabilities and complex communication needs. *Augmentative and Alternative Communication, 32*, 187-197. doi:10.1080/07434618.2016.1213312

Erickson, K., Hatch, P., & Clendon, S. (2010). Literacy, assistive technology, and students with significant disabilities. *Focus on Exceptional Children*, *42*, 1-16. doi:10.17161/foec.v42i5.6904

Freyhoff, G., Hess, G., Kerr, L., Menzel, E., Tronbacke, B., & Van der Veken, K. (1998). *Make it simple: European guidelines for the production of easy-to-read information for people with learning disability*. Brussels: ILSMH European Association. Retrieved from https://digitalcommons.ilr.cornell.edu/cgi/viewcontent.cgi?article=1271&context=gladnetcollect

Hurtado, B., Jones, L., & Burniston, F. (2014). Is easy read information really easier to read? *Journal of Intellectual Disability Research, 58*, 833-829. doi:10.1111/jir.12097

Isaacson, M., & Lloyd, L. (2013). A computerized procedure for teaching the relationship between graphic symbols and their referents. *Assistive Technology, 25*, 127-136. doi:10.1080/10400435.2012.726937

Jones, F. W., Long, K. & Finlay, W. M. (2006). Assessing the reading comprehension of adults with intellectual disabilities. *Journal of Intellectual Disabilities Research 50*, 410-418. doi:10.1111/j.1365-2788.2006.00787.x

Lesch, M. F., & McDevitt, J. R. (2002). Methodological issues in testing comprehension of safety symbols. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 46*, 1744-1747. doi:10.1177/154193120204601912

Lovatt, F. (2017). *Delivery of outcomes under the national disability strategy 2010-2020 to build inclusive and accessible communities.* Australia: AGOSCI, Retrieved from https://www.aph.gov.au/DocumentStore.ashx?id=4307fd3d-0b8c-4cac-9073-68e403d5552c&subId=512133

Mayer-Johnson, R. (2006). *The picture communication symbols.* Solana Beach, CA: Mayer-Johnson.

Nomura, M., Nielsen, G. S., & Tronbacke, B. (2010). *Guidelines for easy-to-read materials. IFLA Professional Reports, No. 120.* The Hague: International Federation of Library Associations and Institutions. Retrieved from https://www.ifla.org/files/assets/hq/publications/professional-report/120.pdf

National Joint Committee for the Communication Needs of Persons with Severe Disabilities. (1992, March). *Guidelines for meeting the communication needs of persons with severe disabilities.* American Speech and Hearing Association, 34 (Supplement #7), 1-8. Retrieved from https://www.asha.org/policy/PS2003-00227/

Office for Disability Issues. (2018). *Accessible communication formats.* London, UK: Office for Disability Issues. Retrieved from https://www.gov.uk/government/publications/inclusive-communication/accessible-communication-formats

O'Neill, T., Light, J., & Pope, L. (2018). Effects of interventions that include aided augmentative and alternative communication input on the communication of individuals with complex communication needs: A meta-analysis. *Journal of Speech, Language, and Hearing Research, 61*, 1743-1765. doi:10.1044/2018_JSLHR-L-17-0132

Parson, S., & Sherwood, G. (2015). A pilot evaluation of symbol-based information in police custody. *British Journal of Learning Disabilities. 44*, 213-224. doi:10.1111/bld.12140

Pufpaff, L. A., Blischak, D. M., & Lloyd, L. L. (2000). Effects of modified orthography on the identification of printed words. *American Journal on Mental Retardation,105*(1), 14-24. doi:10.1352/0895-8017(2000)105<0014:EOMOOT>2.0.CO;2

Poncelas, A., & Murphy, G. (2007). Accessible information for people with intellectual disabilities: Do symbols really help? *Journal of Applied Research in Intellectual Disabilities. 20*, 466-474. doi:10.111/j.1468-3148.2006.00334.x

Ruppar, A. L. (2015). A preliminary study of the literacy experiences of adolescents with severe disabilities. *Remedial and Special Education, 36*, 235-245. doi:10.1177/0741932514558095

Samuels, S. J. (1967). Effects of pictures on learning to read, comprehension and attitudes. *Review of Educational Research, 40*, 397-407. doi:10.3102/00346543040003397

Singh, N. N., & Solman, R. T. (1990). A stimulus control analysis of the picture-word problem in children who are mentally retarded: The blocking effect. *Journal of Applied Behavior Analysis, 23*, 525-532. doi:10.1901/jaba.1990.23-525

Snell, M., Brady, N., McLean, L., Ogletree, B., Siegel, E., Sylvester, L., …Sevcik, R. (2010). Twenty years of communication intervention research with individuals who have severe intellectual and developmental disabilities. *American Journal on Intellectual and Developmental Disabilities, 115*, 364-380. doi:10.1352/1944-7558-115-5.364

Strydom, A., Forster, M., Wilkie, B. M., Edwards, C., & Hall, I. S. (2001). Patient information leaflets for people with learning disabilities who take psychiatric medication. *British Journal of Learning Disabilities, 29*(2), 72-76. doi:10.1046/j.1468-3156.2001.00108.x

Sutherland, R. J., & Isherwood, T. (2016). The evidence for easy-read for people with intellectual disabilities: A systematic literature review. *Journal of Policy and Practice in Intellectual Disabilities, 13*, 297-320. doi:10.1111/jppi.12201

Wolff, J. S., & Wogalter, M. S. (1998). Comprehension of Pictorial Symbols: Effects of Context and Test Method. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 40*, 173-186. doi:10.1518/001872098779480433

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 19-35
Copyright ATIA 2020 ISSN 1938-7261
Available online: www.atia.org/atob

Text-to-Speech Technology: Enhancing Reading Comprehension for Students with Reading Difficulty

Jennifer L. Keelor[1], Nancy Creaghead[2], Noah Silbert[2], Tzipi Horowitz-Kraus[3,4]

[1]Department of Communication, The College of Wooster

[2]Department of Communication Sciences and Disorders, University of Cincinnati

[3]Communication Sciences Research Center, Reading and Literacy Discovery Center, Cincinnati Children's Hospital Medical Center

[4]Educational Neuroimaging Center, Faculty of Education in Science and Technology, Technion, Haifa, Israel

Corresponding Author
Jennifer L. Keelor
330 East University Street
Department of Communication, The College of Wooster
Wooster, OH 44691
Phone: (330) 263-2312
Fax: (513) 771-5599
Email: jkeelor@wooster.edu

Abstract

The aim of this study was to investigate the impact of text-to-speech (TTS) without highlighting, with highlighting, and with increased highlighting rate, on the reading comprehension of children with reading difficulties. Participants read six expository passages under the following conditions: (a) Silent Reading, (b) Reading Aloud, (c) Listening Only, (d) reading with the use of TTS with No Highlighting, (e) reading with the use of TTS with Highlighting and (f) reading with the use of TTS at a Rapid Rate with Highlighting. They answered comprehension questions following each condition. Data were analyzed using a two-tailed paired t-test and a one-way ANOVA. Reading comprehension was significantly higher for the TTS versus No TTS condition. There was no difference in the presentational features. Comprehension scores for TTS with No Highlighting positively correlated with processing speed; Listen Only negatively correlated with read aloud speed. TTS is a useful compensatory reading aid for improving comprehension.

Keywords: assistive technology, text-to-speech, reading comprehension, dyslexia

Introduction

In the recent decades of educational reform, America's public schools have rallied to address reading skills, given the expectations of initiatives such as the No Child Left Behind Act of 2001. This type of initiative has forced students to contend with increasing literacy demands and accelerated instruction in the classroom. Those with learning disabilities and specifically with dyslexia are especially vulnerable in this high-risk environment (Frase-Blunt, 2000). Dyslexia is characterized by difficulties with fluent word recognition, reduced decoding ability, and slow reading rate despite remedial intervention, exposure to written language, and intact intelligence (IDA, 2002). The incidence of developmental dyslexia is determined to be between approximately 10 to 15% of the population in most languages and countries (Fletcher, Lyon, Fuchs, & Barnes, 2007; Youman & Mather, 2012). While students with dyslexia struggle with decoding, this is not necessarily indicative of their comprehension level. However, failure to treat decoding deficits may adversely affect a student's comprehension and ultimately academic success (Flynn, Zheng, & Swanson, 2012). While a Structured Literacy approach (IDA, 2017; Spear-Swerling, 2019) can improve both decoding and comprehension skills, some students will continue to struggle with reading. Therefore, it is imperative that reading aids be comprehensive for students with dyslexia to mitigate the effects of poor literacy skills on academic achievement, self-efficacy, and future success (Undheim, Wichstrom, & Sund, 2011).

While various aspects of reading have been examined in relationship to the challenges that students with dyslexia face, comprehension is the goal of reading and is imperative for school success. Reading comprehension involves constructing and extracting meaning from the text (Snow, 2010). Text comprehension draws upon oral language skills such as vocabulary, grammar, discourse and metalinguistic aptitude, which are necessary for both listening and reading comprehension (Cutting & Scarborough, 2006; Ukrainetz, 2015). Recent literature has also highlighted the importance of intact executive functions for reading comprehension (Sesma, Mahone, Levine, Eason, & Cutting, 2009).
Executive function is a broad term that involves higher-level cognitive abilities that are necessary for independent goal-directed behaviors such as holding and manipulating information in working memory, as well as planning and organizing complex tasks (Denckla, 1989). Increased working memory capacity is linked to improved reading comprehension because of sufficient cognitive resources to simultaneously decode and extract the meaning of words, while recalling previously read information (Sesma et al., 2009). Additionally, Cutting, Materek, Cole, Levine and Mahone (2009) found that participants with specific reading comprehension deficits showed significant weakness in executive function.

Reading fluency, which includes word recognition and decoding, is a fundamental bridge to reading comprehension (Breznitz, 2006; Pikulski & Chard, 2005). Speed in word recognition is one factor that facilitates extracting meaning from text (Torgesen, Rashotte, & Alexander, 2001). Variations in processing speed often determine differences in a student's word recognition (Breznitz, 2006). Literature suggests that efficient processing of orthographic, phonological, and semantic information promotes automatic word recognition and ultimately comprehension (Bowers & Wolf, 1993; Goswami, 1999). Thus, reducing the burden of decoding through instructional aids may be useful in supporting comprehension.

As schools explore ways to boost academic achievement, exploiting assistive technology (AT) to access text is a key approach (Anderson-Inman & Horney, 2007). However, addressing the academic needs of children with disabilities by using AT is not an innovative idea, but rather a federally mandated requirement in the Individuals with Disabilities Education Improvement Act of 2004. This piece of legislation endorsed the benefits of AT by emphasizing that Individual Education Plan teams should consider the use of AT within the child's academic environment (Madlowitz, 2006). Text-to-Speech (TTS) is considered a high-tech AT reading aid (Bouck, 2017). TTS provides readers with audio input as digital text is read aloud with synthetic speech (Anderson-Inman, & Horney, 2007). The aim of this study was to investigate the effective use of TTS features in supporting comprehension in struggling readers.

The potential value of compensatory strategies such as TTS for individuals with reading difficulties is based on learning theories such as Cognitive Load Theory (Pollock, Chandler & Sweller, 2002) and Automaticity Theory (LaBerge & Samuels, 1974). The Cognitive Load Theory purports that learning is best facilitated when information is presented in a way that is efficiently processed in working memory (Chandler & Sweller, 1991). This is especially pertinent to reading because it is a complex task with heavy demands on working memory (Swanson & Siegel, 2001). When word recognition is not automatic, the reading process is slow, placing heavy demands on memory (LaBerge & Samuels, 1974). Slow and labored reading diminishes the ability to address the higher-order processes necessary for comprehending text (Samuels, 1997).

TTS may help reduce cognitive load and increase automaticity for struggling readers. Students using TTS have demonstrated gains in volume of text read while decreasing fatigue and stress (Hecker, Burns, Elkind, Elkind, & Katz, 2002; Hodapp & Rachow, 2010); slower readers have increased reading rate (Elkind, 1998; Sorrell, Bell, & McCallum, 2007); students with learning disabilities have bolstered their reading comprehension (Elkind, Cohen, & Murray, 1993). A longitudinal study of middle school special education students showed a significant positive relationship between use of TTS, reading rate, and comprehension scores (Hodapp & Rachow, 2010). In contrast, Schmitt, Hale, McCallum and Mauck (2010) found no difference between the ability of 25 middle school remedial readers (ages 11 to 15 years) to correctly answer factual and inferential comprehension questions with and without TTS. Despite the lack of information regarding the specific populations who benefit from TTS (Alper & Raharinirina, 2006), Strangman and Dalton (2005) suggest that students with weak word recognition and stronger comprehension skills may benefit more from TTS than students who are weak in both decoding and comprehension.

TTS has several available features such as synchronized highlighting and adjusting the rate of the synchronized voice. Although the previously mentioned TTS studies have typically included TTS with highlighting, (Elkind et al., 1993; Horney et al., 2009; Meyer & Bouck, 2014) and the option to adjust rate to the participant's preference (Elkind et al., 1993; Horney et al., 2009; Izzo, Yurick, & McArrell, 2009; Meyer & Bouck, 2014), the researchers did not examine outcomes related to differences in presentation. In contrast, Sorrell et al. (2007) presented the TTS at a reduced and rapid rate but found no meaningful differences in comprehension when varying the presentation rate. Similarly, Lionetti and Cole (2004) found no differences in fourth and fifth grade poor readers' comprehension related to rate of presentation during listening while reading. More information regarding the executive function abilities related to the beneficial use of TTS presentational features that best support reading comprehension for a specific type of disability is needed (Alper & Raharinirina, 2006; Wood, Moxley, Tighe, & Wagner, 2017). The current study deals with this question.

The aim of this study was to characterize the reading comprehension of children with reading difficulties while using TTS. Specifically, we aimed to determine: 1) if there is a significant difference between reading comprehension scores when reading a passage with TTS compared to without TTS; 2) if there is a significant difference in reading comprehension scores under different TTS conditions (TTS with No Highlighting, TTS with Highlighting, and TTS at a Rapid Rate with Highlighting); and 3) the relationship between reading comprehension scores and executive function abilities when using TTS.

Methods

Participants

Ten 8 to 11-year-old children with reading difficulties (M = 9.36 years, SD = 1.07) participated (8 females, 2 males). The following were inclusion criteria: (a) reading difficulty as measured by scores at or below the 25th percentile on a total of two subtests taken from the following measures: Test of Word Reading Efficiency (TOWRE), (Subtests-Sight Word Efficiency, Phonemic Decoding Efficiency), (Torgesen, Wagner, & Rashotte, 2012); Comprehensive Test of Phonological Processing-Second Edition (CTOPP-2), (Subtest-Elision), (Wagner, Torgesen, Rashotte, & Pearson, 2013); Woodcock Johnson Tests of Achievement-Third Edition (WJ III), (Subtests-Word Identification, Word Attack and Passage Comprehension), (Woodcock, McGrew, & Mather, 2001); Test of Silent Reading Efficiency and Comprehension (TOSREC), (Wagner, Torgesen, & Roshette, 2010); (b) intelligence quotient >85 as measured by the Test of Non-Verbal Intelligence-4th Edition (TONI-4), (Brown, Sherbenou, & Johnsen, 2010); (c) school reported full scale IQ >80 as measured by the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV), (Wechsler, 2003); (d) school reported normal hearing and vision; (e) native speakers of American English; (f) absence of neurological or psychiatric condition. All participants were recruited via flyers during a remedial summer session in a local private school for children with learning disabilities. These participants were recruited as part of a larger study which also investigated reading, eye-tracking, and executive function in children with and without reading difficulties. A neuro-imaging component was included.

Procedure

Behavioral measures. Each participant completed a testing battery that included reading, language, cognitive, and executive function tasks. The following list of testing measures is a comprehensive list that includes the inclusion/exclusion measures as well as additional tests and subtests to further understand the reading profile of each student.

Measures for assessing reading and language. TOWRE (Subtests-Sight Word Efficiency, Decoding

Efficiency), CTOPP-2 (Subtest-Elision), WJ III (Subtests-Word Identification, Word Attack, Passage Comprehension), TOSREC, Peabody Picture Vocabulary Test-Fourth Edition (PPVT-4), (Dunn & Dunn, 2007).

Measures for assessing cognitive ability and executive functions. TONI-4; Wechsler Intelligence Scale for Children-Fourth Edition (WISC-4), (Wechsler, 2003) (Subtests-Processing Speed Index: Digit Span, Coding & Symbol Search); Comprehensive Test of Phonological Processing-Second Edition (CTOPP-2) (Subtests-Rapid Digit Naming, Rapid Letter Naming); Conners 3rd Edition-Parent Survey and Child Self Report Survey (Conners, 2009); Behavior Rating Inventory of Executive Function (BRIEF) Parent Form (Gioia, Isquith, Guy & Kenworthy, 2000).

The test battery was administered to each child individually in a quiet room. The total testing battery lasted approximately two hours (see Table 1 for participant testing results). Students took a 15-minute break after the first hour. The Conners and BRIEF parent surveys were completed at home and returned at the time of the experimental session.

Text-to-Speech Design

This study employed a repeated measures design wherein each subject read the same six passages which were randomized across six conditions: (a) Silent Reading, (b) Reading Aloud, (c) Listening Only with digitized speech and no text, (d) reading with the use of TTS with No Highlighting, (e) reading with the use of TTS with Highlighting and (f) reading with the use of TTS at a Rapid Rate with Highlighting. The independent variable was the six experimental conditions. The dependent variable was the number of accurately answered comprehension questions following each passage.

TTS reading materials. The students read six expository passages derived from the Level 2 Reading Comprehension Cards, (Lingui-Systems, 2007). The mean Flesch-Kincaid Readability Level for the six passages was 4.8 with a range of 4.5 to 5.3 (see Appendix A). All six passages contained 7 to 8 lines of text with a mean of 110 words and a range of 102 to 127 words per passage. Passage length was limited to accommodate the visual field appropriate for collecting eye-tracking data for the larger study. A linguist experienced in child language development reviewed and made modifications to the passages for consistency of total length, sentence complexity, word frequency and cohesion.

TTS software. The six passages were downloaded into TTS software (e.g. Kurzweil 3000TM) on a laptop computer. The Listen Only, TTS with No Highlighting, and TTS with Highlighting conditions were presented at a reading rate set at 150 words per minute (Hasbrouck & Tindal, 2006). The rate for the TTS at a Rapid Rate with Highlighting was set at 225 words per minute, with a 50% increase in rate, as determined to be most comfortable without distorting the synthesized voice. All passages were visually displayed on the computer screen for each condition, except for the Listen Only condition. During this condition, the participant was shown an X on the computer screen while listening to the passage read with a digitized voice.

TTS presentation. The participants completed one experimental session. During the experimental session, the participants read six expository passages under each of the six conditions. Each child was tested individually. The principal investigator (PI) provided scripted verbal instructions to the participant before each experimental condition. The student was instructed to read the passage silently for all conditions except the Read Aloud and the Listen Only conditions. During the Listen Only condition, the child was told to watch the X on the screen as the computer read the passage with the synthesized voice. Each passage was read only once. The text disappeared immediately from the computer screen after the last word was read.

Following the reading of each passage, the participants responded to three comprehension questions in a multiple-choice format (three choices per question) to test their comprehension of each passage in each condition. The test items were read to the children by the PI, and the child had a copy of the written questions and answers. The child gave a verbal response of the answer.

Data Analysis

Behavioral measures data analysis. Group descriptive statistics, including mean and standard deviation, were gathered for all reading, language, cognitive, and executive function measures.

Text-to-speech data analysis. To explore the first research question, the investigators employed a two-tailed paired t-test comparing the comprehension scores as a total of the three NO TTS treatment conditions with the total of the three TTS conditions. For the second question, a single factor analysis of variance (ANOVA) was performed to determine if there was a significant difference among the comprehension scores on the three TTS conditions.

Correlation of behavioral and TTS measures. A Pearson correlation was performed to establish the relationship between participant scores on the behavioral measures and the number of correct comprehension responses under the six experimental conditions.

Results

Behavioral Measures

The mean scores for the participants on each behavioral measure are shown in Table 1.

Reading measures. Children with reading difficulties showed impaired sight word recognition (TOWRE-SWE) and nonsense word decoding (TOWRE-PDE) in a timed condition. They also had difficulty with elision on a phonological processing task. Sentence level comprehension and passage level comprehension were also below average for these children.

Cognitive and executive function measures. The average standard non-verbal intelligence score fell within the average range, while the average processing speed fell within a relatively low range. Executive functions scores were elevated for the probability of attention issues and mildly clinically elevated for working memory. However, the global executive composite score for executive functioning fell within the normal range for these participants.

Table 1: Participant Scores on Behavioral Measures

Behavioral Tests	***M***	***SD***	***Range***
Reading/Language			
CTOPP-2 Elision	7.7	3.12	5-14
PPVT	98.8	8.40	80-112
TOSREC	83.1	12.41	55-99
TOWRE-2 SWE	83.5	12.96	61-95
TOWRE-2 PDE	80.3	10.68	63-95
WJ III SWE	86.9	10.13	62-98
WJ III PDE	89.9	8.06	74-97
WJ III Pass Comp	81.4	14.08	50-101
Cognitive/Executive Function			
CTOPP-2 RLN	6.4	3.34	1-11
WISC-IV PSI	88.4	22.31	50-121
BRIEF-2 GEC	58.0	9.60	41-71
Conner's 3	46.6	2.88	46.99

Note: [1]The following subsets used scaled scores (7-13 average range): Comprehensive Test of Phonological Processing-Second Edition (CTOPP-2) Elision, Rapid Digit Naming (RDN), Rapid Letter Naming (RLN).
[2]The following tests used standard scores (mean of 100): Test of Silent Efficiency & Comprehension (TOSREC); Test of Word Reading Efficiency (TOWRE-2)-Sight Word Efficiency (SWE) and Phonemic Decoding Efficiency (PDE) lists; Woodcock Johnson (WJ-III)-Sight Word Efficiency (SWE), Phonemic Decoding Efficiency, Passage Comprehension; Peabody Picture Vocabulary (PPVT); Test of Non-Verbal Intelligence (TONI-4); Weschler Intelligence Scale for Children (WISC-IV)-Processing Speed Index (PSI).
[3]The following tests used Tscores (< 60 average range): Behavior Rating Inventory of Executive Function (BRIEF-2)-Global Executive Composite (GEC); Conner's 3.

Reading Conditions

Comparison of No TTS and TTS conditions. A two-tailed paired t-test was used to compare the comprehension scores as a total of the three No TTS conditions with the total of the three TTS conditions. The independent variable was the six experimental conditions grouped by the three No TTS conditions (Silent Read, Read Aloud, and Listen Only) and the three TTS conditions (TTS with No Highlighting, TTS with Highlighting, and TTS at a Rapid Rate with Highlighting). The dependent variable was the total number of comprehension questions answered correctly after the three passages in the No TTS and TTS conditions. The mean number of comprehension questions answered correctly after each of the six passage conditions and the means for the combined No TTS & TTS conditions are presented in Table 2.

There were no outliers in the comprehension score data set and the assumption of homogeneity of variance was met. A two-tailed paired t-test was performed. There was a significant difference between the mean score for the No TTS (M = 5.7, SD = 2.01) and the mean score for the TTS (M = 7.2, SD = 1.08) conditions; $t(9) = 2.26$, $p = 0.04$, showing a medium effect size. Thus, the students showed increased comprehension of the expository passages when utilizing TTS versus when not using TTS.

Table 2: Comprehension Scores for Each Experimental Condition

Condition	***M (out of 3)***	***SD***	***% Correct***
SR	1.6	0.70	53%
RA	2.2	0.63	73%

Condition	*M (out of 3)*	*SD*	*% Correct*
LO	1.9	0.74	63%
Total No TTS (SR + RA + LO)	5.7	1.42	63%
TTS-NH	2.4	0.70	80%
TTS-H	2.4	0.70	80%
TTS-RR	2.4	0.70	80%
Total TTS (TTS-NH + TTS-H + TTS-RR)	7.2	1.03	80%

Note: SR = Silent Read; RA = Read Aloud; LO = Listen Only; TTS-NH = Text-to-Speech with No Highlighting; TTS-H = Text-to-Speech with Highlighting; TTS-HRR = Text-to-Speech with Highlighting at a Rapid Rate

Comparison of TTS conditions. The scores under the three TTS conditions were examined to determine if there was a significant difference in the performance of the students when using specific TTS presentational features.

Table 3: t-Test Results between Comprehension Scores and Experimental Conditions

Conditions	*t*	*p*	*d*
SR & RA	-2.71	0.02	-0.783
SR & LO	-1.00	0.34	0.289
SR & TTS-NH	-2.23	0.05	-0.645
SR & TTS-H	-2.45	0.04	-0.708
SR & TTS-HRR	-3.21	0.01	-0.928
RA & LO	1.00	0.34	0.289
RA & TTS-NH	0.51	0.62	0.147
RA & TTS-H	-0.56	0.59	-0.162
RA & TTS-HRR	-0.80	0.44	-0.231
LO & TTS-NH	-1.86	0.10	-0.538
LO & TTS-H	-1.46	0.18	-0.422
LO & TTS-HRR	1.34	0.21	-0.387
TTS-NH & TTS-H	0.00	1.0	0.000
TTS-NH & TTS-HRR	0.00	1.0	0.000
TTS-H & TTS-HRR	0.00	1.0	0.000

Note: SR = Silent Read; RA = Read Aloud; LO = Listen Only; TTS-NH = Text-to-Speech with No Highlighting; TTS-H = Text-to-Speech with Highlighting; TTS-HRR = Text-to-Speech with Highlighting at a Rapid Rate

The independent variables included the three TTS conditions: TTS with No Highlighting, TTS with Highlighting, TTS at a Rapid Rate with Highlighting. The dependent variable was the number of correctly answered comprehension questions for each passage. A single-factor ANOVA was performed. There was no significant difference among the comprehension scores (M = 2.4, SD = 0.48) resulting from the three TTS conditions; $F(2, 27)$, < 1, p >.05. The mean of the comprehension scores was identical in each of the TTS conditions. Because silent reading is standard practice for gaining information and demonstrating knowledge in school, the Silent Read condition was compared to all other conditions. T-tests revealed a significant difference between Silent Read and all three TTS conditions with better scores under all TTS conditions with medium to large effective sizes. See Table 3.

Correlation between behavioral measures and TTS performance. Participant scores on the behavioral testing were correlated with number of correct comprehension responses under each of the six conditions. Higher comprehension scores were positively correlated with processing speed (WISC-IV, $p < .03$) and negatively correlated with Read Aloud time ($p < .02$). The following correlations were significant: (a) TTS with No Highlighting was positively and strongly correlated $r(8) = .687$, $p < .05$ with processing speed as measured by the WISC-IV. Participants with faster processing speed had increased comprehension using TTS with No Highlighting. (b) Listen Only was negatively and strongly correlated $r(8) = -.736$, $p < .05$ with total Read Aloud time. Faster readers had better auditory comprehension. The remainder of the correlations were not significant. The results are shown in Table 4.

Table 4: Correlations between Experimental Conditions and Behavioral Tests

Conditions	***Test***	***r***	***p***
LO	RA Time	-0.73	≤ 0.015
TTS-NH	PSI	0.68	≤ 0.028
TTS-H	TOSREC	-0.57	≤ 0.081 NS
TTS-HRR	CTOPP-2	0.51	≤ 0.125 NS
LO	CTOPP-2	-0.44	≤ 0.195 NS

Note: No TTS Conditions: SR = Silent Read, RA = Read Aloud, LO = Listen Only; TTS Conditions: TTS-NH = Text-to-Speech with No Highlighting, TTS-H = Text -to-Speech with Highlighting, TTS-HRR = Text-to-Speech with Highlighting at a Rapid Rate; NS = Not Significant. Significance set at p *= 0.01 and* p *= 0.05.*

Discussion

This study examined the impact of Text-to-Speech (TTS) on the reading comprehension of students with reading difficulties. We found that using TTS was related to higher reading comprehension scores compared to not using TTS, but the specific presentational features of TTS were not related to increased comprehension. The correlation between behavioral testing measures and the six experimental conditions was also examined. Children with faster processing speed showed better comprehension following the use of *TTS with No Highlighting*. Faster readers had better auditory comprehension as evidenced by their performance on *Listen Only.*

Use of TTS

The results show that TTS was beneficial in bolstering the reading comprehension of these struggling readers. Comprehension scores were better than Silent Read under all TTS conditions. These findings corroborate results of previous studies that point to the effectiveness of this compensatory reading strategy (Elkind et al., 1993; Hecker et al., 2002; Hodapp & Rachow, 2010; Izzo et al., 2009; Meyer & Bouck, 2014). The successful use of TTS has been broadly based on cognitive theories such as the Cognitive Load Theory which denotes that information should be delivered in a way that reduces unnecessary load on working memory (Chandler & Sweller, 1991). This is especially important while reading, because struggling readers often have difficulty with working memory (De Jong, 1998; Swanson & Siegel, 2001). It is understood that oral reading fluency is a marker of overall reading competence (Fuchs, Fuchs, Hosp, & Jenkins, 2001). Automaticity Theory states that as the reading of words becomes more automatic, fewer cognitive resources need to be apportioned to this task, so more energy can be designated to comprehension (LaBerge & Samuels, 1974). If using TTS can reduce labored decoding, more cognitive resources can be allocated to comprehending the text.

Presentational Features of TTS

The results demonstrate no differences in the reading comprehension scores related to specific presentational features of TTS. The mean numbers of correct responses in the TTS with No Highlighting, TTS with Highlighting, and TTS at a Rapid Rate with Highlighting conditions were exactly the same. As such it is not possible to determine which features associated with TTS may be most helpful in supporting reading comprehension for students with reading difficulties. Although we could not specify which features were most beneficial, the results of this study demonstrate that there is something valuable about TTS that is helping children read and comprehend more successfully. The one feature in common with all the TTS conditions is that the student had auditory input to supplement the visual text. This suggests that the addition of auditory input may be the key factor in enhancing reading comprehension using TTS.

While the presence of auditory input across all TTS conditions suggests the benefit of that component, the possible role of other features such as highlighting or rapid rate is still not clear. The Modality Principle (Low & Sweller, 2005) suggests that spreading the cognitive load across the auditory and visual aspects of working memory may have contributed to the overall difference between the TTS and No TTS conditions. This inclusion of both auditory and visual modalities may be adequate for reducing cognitive load. The specific visual (no highlighting, highlighting, and highlighting at a rapid rate) and auditory (normal rate and rapid rate) presentations may not add further benefit. However, passage length may be a factor in increasing cognitive load. The passages in this study averaged 110 words in length, which may not have challenged cognitive load sufficiently to delineate how particular features may contribute to assisting with comprehension of larger volumes of text.

TTS at a Rapid Rate with Highlighting was included as a condition because an accelerated reading rate has been found to be beneficial to children with reading difficulty (Breznitz, 1987; Horowitz-Kraus & Breznitz, 2013; Horowitz-Kraus, Cicchino, Amiel, Holland, & Breznitz, 2014). The TTS at a Rapid Rate with Highlighting condition was established to better understand the connection between processing rate and reading success. No differences were found between the performance of participants during the TTS conditions at a typical rate versus TTS at a Rapid Rate with Highlighting. These findings are similar to those of Sorrell et al. (2007), but diverge with those of Breznitz (1987), who found a positive relationship between faster rate and increased comprehension for first graders. The different results may be related to the higher language and content demands of upper elementary text. In contrast to the current study, participants in the Breznitz study were beginning readers and were not identified as students with reading difficulties. The struggling readers in our study may not have the resources to increase comprehension with a faster rate as did the typical first graders. Without further research, the impact of rate of TTS presentation on comprehension is unclear.

Correlations Between Reading Conditions and Behavioral Testing

Additional insight regarding the effect of the presentational features on reading comprehension may be gathered through examining their relationship to other characteristics of the readers such as executive function and processing speed. Processing speed as measured by the WISC-4 Processing Speed Index was not correlated with comprehension scores following reading while using TTS at a Rapid Rate with Highlighting. It would seem logical that the speed at which a student can process information would impact their comprehension of text delivered at a faster rate since it is in line with theories regarding the beneficial effect of fluency on reading comprehension (Breznitz, 2006). The highlighting may have been too fast to be facilitative or may have been distracting to the readers. Further research is needed to understand this relationship. However, students with a faster processing speed as measured by the WISC-IV Processing Speed Index had more success with TTS when it was not combined with the highlighting feature. It seems plausible that they would want to read at their own comfortable rate, which may be faster than the highlighting, which was set at (150 WPM).

The relationship between the *Listen Only* condition and the time required to read one of the expository fourth grade passages used in this study indicates that the faster readers had better auditory language comprehension. This conveys a connection between spoken and written language comprehension, which is broadly supported in the literature (Catts, 1993; Kim, Park, & Park, 2015). Because this study did not include a listening comprehension measure as part of the testing battery, the relationship between ability to process spoken language and decoding speed cannot be explored further. This is an important link to consider. Previous findings report that poorer readers are also poorer listeners and show more diffused brain activation when listening (Horowitz-Kraus, Buck & Dorrman, 2016). Listening comprehension is critical for TTS to be useful.

Limitations and Future Research

This study has several limitations that may reduce the generalizability of the data. Participants included a small number of children who were available through a summer academic support program. The group was lacking in racial and socioeconomic diversity. Due to the small sample size the results can best serve as suggestions for what type of relationships might be obtained with a larger sample size and a more focused design. The statistical analysis employed with this data set was parametric in nature (ANOVA, t-tests). Considering the smaller sample size contained in this study, the use of non-parametric equivalents may be considered a more common approach to the statistical analysis. However, non-parametric statistics could be more problematic with a small sample size, since they often have inferior power when compared to analogous parametric statistics for a given situation.

The stimulus materials included expository passages that were short in length with a small number of comprehension questions (3). Longer passages would more closely represent the volume of text that students are typically expected to read, and thus would provide more realistic challenges to their reading comprehension skills and perhaps allow for the potential benefits of different presentational features to be evidenced. Longer passages would also accommodate more questions per passage to provide a greater range of scores to facilitate statistical analysis and reduce error due to guessing.

Future research could incorporate a measure of spoken language skills, especially listening comprehension, in order to examine the relationship between listening comprehension and reading comprehension scores when using TTS. Students with reading difficulties often have concomitant disabilities such as Attention Deficit Hyperactivity Disorder (ADHD). Future studies could further examine the relationship between attention and reading comprehension. Incorporating eye-tracking data during the reading task may give information regarding the child's attention to the text as well as other reading behaviors.

Outcomes and Benefits of AT

The results of this study substantiate previous research in validating the effectiveness of TTS in augmenting the reading comprehension of children with reading difficulties. This outcome is critically important in advocating the role of assistive technology, specifically TTS, as an effective compensatory reading strategy for struggling readers. Increasing reading comprehension with TTS allows students with reading difficulty to not only access but also comprehend text that is more commensurate with their typical peers. This has positive implications in overall academic success, self-esteem, and self-efficacy. While the results were inconclusive for which presentational features best support the reading process for this population, correlations between specific behavioral measures (i.e., processing speed, reading rate) and comprehension resulting from specific presentational features were found to help guide further research.

Target Audience and Relevance

This study has relevance for educators, special education educators, speech-language pathologists, assistive technology specialists, and faculty in higher education. Discussion of specific TTS features, such as highlighting and reading rate, may also inform future studies and clinical practices for both children with developmental disorders and adults with acquired disorders (e.g., aphasia, traumatic brain injury).

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author(s) of this paper.

References

Alper, S., & Raharinirina, S. (2006). Assistive technology for individuals with disabilities: A review of the literature. *Journal of Special Education, 21*, 47-64.

Anderson-Inman, L., & Horney, M. A. (2007). Supported eText: Assistive technology through transformations. *Reading Research Quarterly, 42*, 153-160.

Breznitz, Z. (1987). Increasing first graders' reading accuracy and comprehension by accelerating their reading rates. *Journal of Educational Psychology, 79*, 236-242.

Breznitz, Z. (2006). *Fluency in reading. Synchronization of processes.* Mahwah: Lawrence Erlbaum.

Bouck, E. C. (2017). *Assistive technology.* Los Angeles, CA: SAGE.

Bowers, P. G., & Wolf, M. (1993). Theoretical links among naming speed, precise timing mechanisms and orthographic skill in dyslexia. *Reading and Writing, 5*, 69-85.

Brown, L., Sherbenou, R. J., & Johnsen, S. K. (2000). *Test of nonverbal intelligence-Fourth edition (TONI-4)*. Austin, Texas: Pro-Ed.

Catts, H. W. (1993). The relationship between speech-language impairments and reading disabilities. *Journal of Speech and Hearing Research, 45*, 948-958.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 84*, 293-332.

Conners, C. K. (2009). *Conners, Third edition.* North Tonowanda, NY: Multi-Health Systems.

Cutting, L. E., Materek, A., Cole, C. A. S., Levine, T. M., & Mahone, E. M. (2009). Effects of fluency, oral language and executive function on reading comprehension performance. *Annals of Dyslexia, 59*, 34-54.

Cutting, L. E., & Scarborough, H. S. (2006). Prediction of reading comprehension: Relative contributions of word recognition, language proficiency, and other cognitive skills can depend on how comprehension is measured. *Scientific Studies of Reading 10*, 277-299.

De Jong, P. F. (1998). Working memory deficits of reading disabled children. *Journal of Experimental Child Psychology, 70*, 75-96.

Denckla, M. B. (1989). Executive function, the overlap zone between attention deficit hyperactivity disorder and learning disabilities. *International Pediatrics*, *4*, 155-160.

Dunn, L. M., & Dunn, D. M. (2007). *Peabody picture vocabulary test-Fourth edition (PPVT-4).* Bloomington, MN: Pearson.

Elkind, J. (1998). *A study of the efficacy of the Kurzweil 3000 reading machine in enhancing poor reading performance*. Portola Valley, CA: Lexia Institute.

Elkind, J., Cohen, K., & Murray, C. (1993). Using computer-based readers to improve reading comprehension of students with dyslexia. *Annals of Dyslexia, 43*, 238-259.

Frase-Blunt, M. (2000). High stakes testing a mixed blessing for special students, *CEC Today, 7*(2), 1,5, 7, 15.

Fletcher, J. M., Lyon, G. R., Fuchs, L. S., & Barnes, M. A. (2007). *Learning disabilities: From identification to intervention*. New York: Guilford.

Flynn, L. J., Zheng, X., & Swanson, H. I. (2012). Instructing struggling older readers: A Selective meta-analysis of intervention research. *Learning Disabilities Research and Practice 27*(1), 21-32.

Fuchs, L. S., Fuchs, D., Hosp, M. K., & Jenkins, J. R. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. *Scientific Studies of Reading, 5*, 239-256.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). *Behavior rating inventory of executive function (BRIEF).* Lutz, FL: PAR

Goswami, U. (1999). Integrating orthographic and phonological knowledge as reading develops. Onsets, rimes, and analogies in children's reading. In R. M. Klien & P. A. McMullen (Eds.), *Converging methods for understanding reading and dyslexia: Language, speech and communication* (pp. 57-75). Cambridge, Massachusetts: MIT Press.

Hasbrouk, J. & Tindal, G. A. (2006). Oral reading fluency norms: A valuable assessment tool for teaching teachers. *The Reading Teacher, 59*, 636-644.

Hecker, L., Burns, L., Elkind, J., Elkind, K., & Katz, L. (2002). Benefits of assistive reading software for students with attention disorders. *Annals of Dyslexia, 52*, 243-272.

Hodapp, J. B., & Rachow, C. (2010). Impact of text-to-speech software on access to print: A longitudinal study. In S. Seok, E.E. Meyen, & B. DaCosta (Eds.) *Handbook of research on human cognition & assistive technology* (pp. 199-219). Hershey, PA: IGI Global.

Horney, M. A., Anderson-Inman, L., Terrazas-Arellanes, F., Schulte, W., Mundorf, J., Wiseman, S., Smolkowski, K., Katz-Buonihcontro, J., & Frisbee, M. L. (2009). Exploring the effects of digital note taking on student comprehension of science texts. *Journal of Special Education Technology, 24*(3), 45-61.

Horowitz-Kraus, T. & Breznitz, Z. (2013). Can reading rate acceleration improve error monitoring and cognitive abilities underlying reading in adolescents with reading difficulties and typical readers? *Brain Research, 1544*, 1-14.

Horowitz-Kraus, T., Buck, C. & Dorrman, D. (2016). Altered neural circuits accompany lower performance during narrative comprehension in children with reading difficulties: an fMRI study. *Annals of Dyslexia, 66*, 301-318.

Horowitz-Kraus, T., Cicchino, N., Amiel, M., Holland, S., & Breznitz, Z. (2014). Reading improvement in English- and Hebrew-speaking children with reading difficulties after reading acceleration training. *Annals of Dyslexia, 64*, 183-201.

Individuals with Disabilities Education Improvement Act, 20 U.S.C. § 1400 *et seq.* (2004).

International Dyslexia Association (2002). *Dyslexia definition*. Retrieved June 13, 2019, from https://dyslexiaida.org/definition-of-dyslexia/

International Dyslexia Association (2017). *Effective reading instruction for students with Dyslexia*. Retrieved December 10, 2019, from https://dyslexiaida.org/effective-reading-instruction/

Izzo, M. V., Yurick, A., & McArrell, B. (2009). Supported eText: Effects of text-to-speech on access achievement for high school students with disabilities. *Journal of Special Education Technology, 24*(3), 9-20.

Kim, Y-S. G., Park, C., & Park, Y. (2015). Dimensions of discourse-level oral language skills and their relation to reading comprehension and written composition: An exploratory study. *Reading and Writing, 28*, 633-654.

La Berge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology, 6*, 293-323.

Lionetti, T.M., & Cole, C.L. (2004). A comparison of the effects of two rates of listening while reading on oral reading fluency and reading comprehension. *Education and Treatment of Children, 27*, 114-129.

Low, R. & Sweller, J. (2005). The modality principle in multi-media learning. In Mayer, R.E. (Ed.), *The Cambridge handbook of multi-media learning* (pp.147-158). New York: Cambridge University Press.

Madlowitz, M. (2006). *What every teacher should know about IDEA 2004.* Boston: Allyn & Bacon.

Meyer, N. K., & Bouck, E. C. (2014). The impact of text-to-speech on expository reading for adolescents with LD. *Journal of Special Education Technology, 29*(1), 21–33.

No Child Left Behind Act, 20 U.S.C. § 6301 *et seq.* (2001).

Pikulski, J. J., & Chard, D. J. (2005). Fluency: Bridge between decoding and reading comprehension. *The Reading Teacher, 58*, 510–519.

Pollock, E., Chandler, P., & Sweller, J. (2002). Assimilating complex information. *Learning and Instruction, 12*, 61-86.

Samuels, S. J. (1997). The importance of automaticity for developing expertise in reading. *Reading and Writing Quarterly, 13*, 107-121.

Schmitt, A. J., Hale, A., McCallum, E., & Mauck, B. (2010). Accommodating remedial readers in the general education setting: Is listening-while-reading sufficient to improve factual and inferential comprehension? *Psychology in the Schools, 48*(1), 37-45.

Sesma, H. W., Mahone, E. M., Levine, T., Eason, S. H., & Cutting, L. E. (2009). The contribution of executive function to reading comprehension. *Child Neuropsychology, 15*, 232-246.

Snow, C. E. (2010). Reading comprehension: Reading for learning. *International Encyclopedia of Education, 5*, 413-418.

Spear-Swerling, L. (2019). Structured literacy and typical literacy practices: Understanding differences to create instructional opportunities. *Teaching Exceptional Children, 51*(3), 201-211.

Sorrell, C. A., Bell, S. M., & McCallum, S. (2007). Reading rate and comprehension as a function of computerized versus traditional presentation mode: A preliminary study. *Journal of Special Education Technology, 22*(1), 1-12.

Strangman, N., & Dalton, B. (2005). Using technology to support struggling readers: A review of the research. In D. Edyburn, K. Higgins, & R. Boone (Eds.), *Handbook of special education technology research and practice* (pp. 545-569). Port Chester, NY: National Professional Resources.

Swanson, H. L., & Siegel, L. (2001). Learning disabilities as a working memory deficit. *Issues in Education: Contributions of Educational Psychology, 7*, 1048.

Torgesen, J. K., Rashotte, C. A., & Alexander, A. W. (2001). Principles of fluency instruction in reading: Relationships with empirical outcomes. In M. Wolf (Ed.), *Dyslexia, fluency, and the brain* (pp. 307-331). Timonium, MD: York Press.

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (2002). *Test of word reading efficiency-Second edition (TOWRE-2)*. Austin, Texas. Pro-Ed.

Ukrainetz, T. A. (2015). *School-age language intervention: Evidence-based practices.* Austin, TX: Pro-Ed.

Undheim, A. M., Wichstrom, L., & Sund, A. M. (2011). Emotional and behavioral problems among school adolescents with and without reading difficulties as measured by the youth self-report: A one-year follow-up study. *Scandinavian Journal of Educational Research, 55*, 291-305.

Wagner, R. K., Torgesen, J. K., Rashotte, C. A., & Pearson, N. I. (2010). *Test of silent reading efficiency and comprehension (TOSREC).* Austin, Texas: Pro-Ed.

Wagner, R. K., Torgesen, J. K., Rashotte, C. A., & Pearson, N. I. (2013). *Comprehensive test of phonological processing-Second edition (CTOPP-2).* Austin, TX: Pro-Ed.

Wechsler, D. (2003). *Wechsler intelligence scale for children-Fourth edition (WISC-IV).* Bloomington, MN: Pearson.

Wood, S. G., Moxley, J. H., Tighe, E. L., & Wagner, R. K. (2017). Does text-to-speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *Journal of Learning Disabilities, 50*(1), 1–12.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III-Tests of achievement.* Itasca, IL: Riverside Publishing Company.

Youman, M., & Mather, N. (2012). Dyslexia laws in the USA. *Annals of Dyslexia* doi:10.1007/s11881-012-0076-2.

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 36-51
 ISSN 1938-7261
Available online: www.atia.org/atob

The Development of an Assistive Technology Toolkit for Early Literacy Instruction

Ruby Natale, PhD, PsyD, Christina Sudduth, MPH, Monica Dowling, PhD, Sarah Messiah, PhD, MPH, Christina Nunez, MS, Michelle Schladant, PhD, ATP

University of Miami Miller School of Medicine

Corresponding Author
Michelle Schladant, PhD, ATP
University of Miami Miller School of Medicine
1601 NW 12th Avenue, Room 3047
Miami, FL 33136
Phone: (305) 243-4466
Fax: (305) 243-5978
Email: mschladant@med.miami.edu

Abstract

Despite evidence supporting the use of assistive technology (AT) to improve early literacy outcomes, only a small percentage of preschool age children with disabilities utilize such devices and services. The goal of the Step Up AT to Promote Early Literacy Project is to develop an evidence-based training program to increase teacher and parent knowledge, confidence, and use of AT practices to promote inclusion and improve early literacy skills for this population. During years 1 and 2, a 6-month in-person and online training program was developed and implemented across 3 childcare centers serving children 3 to 5 years of age (n = 56), their primary caregivers (n = 56), and teachers and teacher aides (n = 36). This paper discusses how the program evolved over a period of two years to: a) better address the needs of children from Spanish-speaking and low-income families, b) incorporate a range of “low-tech” to “high-tech” AT options to serve a diverse population with various abilities, and c) enhance the utility of the toolkit for parents and teachers.

Keywords: early childhood, assistive technology, early literacy, professional development

Introduction

Early literacy is a national priority and critical to school success (National Institute for Literacy, 2009). Despite provisions for special education services mandated by the Individuals with Disabilities Education Act, the majority of young children with disabilities, particularly those from low socioeconomic backgrounds or who speak English as a second language, are delayed in early literacy skills compared to their typically developing peers (Burne, Knafelc, Melonis, & Heyn, 2011; Floyd, Smith Canter, & Judge, 2008; Teale, Hoffman, & Paciga, 2014). There is promising evidence that assistive technology (AT) can improve early literacy outcomes for young children with a range of disabilities (Dunst, Trivette, & Hamby, 2012; Satterfield, 2016). However, national reports have consistently documented that less than 10 percent of children ages 3 to 5 served under IDEA, Part B, received AT services in 2015 (U.S. Department of Education, 2015).

The National Institute for Early Education Research documented that 74% of preschool teachers serving children 3 to 5 years of age in Head Start programs held a bachelor's or advanced degree (Kaplan & Mead, 2017). The majority, however, are not trained in special education, and even less have had training in the use of AT (Baker, 2014; Beard, Bowden Carpenter & Johnston, 2011; Hemmingsson, Lidstrom, & Nygard, 2009). Increases in the numbers of children with complex communication needs, including autism spectrum disorders, Down syndrome, and cerebral palsy, who require AT, underscore the urgent need to develop effective research-based interventions to improve educators' ability to use AT (Light & McNaughton, 2012). In this case, AT may include a range of "low-tech" to "high-tech" tools and strategies, including visual supports, switches, communication devices and applications, adaptive books, writing tools, and more (Floyd et al., 2008; Simpson, McBride, Spencer, Lowdermilk, & Lynch, 2009).

While training has been minimal, even when teachers and parents had AT knowledge, it did not always translate into appropriate use of the technology (Baker, 2014; Burne et al., 2011; Neuman & Cunningham, 2009; Satterfield, 2016; Cardon, Wilcox, & Campbell, 2011). Promoting best AT practices for shared literacy experiences in early childhood programs and at home is critical (National Institute for Early Education Research [NIEER], 2006). Furthermore, training parents and teachers to be effective communication partners can lead to important social experiences that promote early literacy development (Light & McNaughton, 2012). AT provides additional support in both of these domains (Floyd et al., 2008).

There are many challenges in determining how to prepare early childhood teachers to support the needs of young children with disabilities with AT strategies (Friedman, Woods, & Salisbury, 2012; Nikolopoulou & Gialamas, 2015; Simpson et al., 2009; Smith & Smith, 2004). In particular, training for both the use of low-tech and high-tech AT options is required (Baker, 2014; Hill & Flores, 2014; Karlsson, Johnston, & Barker, 2017; Stanger, Mims, Wood, & Ahlgrim-Delzell, 2016). Short-term professional development (PD) activities, which are often the standard of practice, have limited effectiveness on changing teachers' practices in the classroom (Diamond & Powell, 2011; Dunst, Bruder, & Hamby, 2015; Parette & Stoner, 2008; Smith & Smith, 2004). Therefore, there is a strong need for innovative professional development opportunities, especially among teachers of children living in low-resource communities and for English language learners. Students in these areas have shown to benefit the most from teacher quality, as well as collaboration between the home and school environments (McCray, Brownell, & Lignugaris, 2014; NIEER, 2006; NIEER, 2011).

Target Audience and Relevance

Step Up AT to Promote Early Literacy Project (Step Up AT) was a training program for teachers and parents of children with disabilities, 3 to 5 years of age. The team designed the program to increase the knowledge of evidenced-based AT practices, and promote the use of AT, for the inclusion and early literacy skills development of preschool children with disabilities. The program extended beyond traditional professional development practices by integrating (a) self-guided online learning modules for teachers and parents in English and Spanish, (b) access to AT devices and resources through a classroom toolkit and the Step Up AT Lending Library, and (c) training via coordinated coaching and workshops.

The team also designed the intervention to better equip teachers and parents to support English language learners in emergent literacy activities. Step Up AT was unique in that it was developed in a culturally and linguistically diverse community where the majority of the population was from a minority background, approximately 52% Latino from Caribbean, Central and Latin American descent and 23% Black from African American, Haitian or Caribbean descent, with 60% of the population speaking a language other than English in the home (United States Census Bureau, 2017). The project also emphasized the training of teachers and teacher aides in community-based Head Start and voluntary pre-kindergarten childcare centers with inclusion programs where few were trained in AT and special education. Most held the minimum requirement for a preschool teacher, a Child Development Associate credential (CDA).

The Step Up AT project was a collaboration between a University Center for Excellence in Developmental Disabilities Education, Research, and Service (UCEDD) and a statewide AT Act Program. Therefore, other stakeholders that might benefit from this work are funding and policy agencies that work with early learning or special education programs at the local, state, or national level. School districts with exceptional student education (ESE) divisions for pre-kindergarten, as well as organizations that are part of the statewide and national networks of AT, and intellectual and developmental disability services would find this work relevant to their priorities.

The purpose of this manuscript is to describe the development of the Step Up AT toolkit as well as lessons learned over the two years of piloting the professional development resource in a multi-lingual, low-income, low-resource population. The following will describe the major components of the comprehensive toolkit and the pedagogy used by the research team to inform design, delivery in the field, and adaptations between each implementation year.

Development of the Step Up AT Toolkit

The Step Up AT toolkit was comprised of online learning modules, a curated selection of assistive technology (AT) for early literacy learning, and a coaching curriculum that was to be administered both in-person and via videoconferencing. An interdisciplinary team of psychology, special education, and AT professionals contributed to the development of the Step Up AT toolkit, building upon previous work in the field of early childhood special education and recommended practices as outlined by the Division of Early Childhood (DEC; Division of Early Childhood, 2014). The research team also included a partnership with the statewide AT agency to provide participants ongoing access to an AT lending library. The use of the device lending program increased opportunities for families to explore AT options and make informed decisions before investing in personal equipment (Wilcox, Dugan, Campbell, & Guimond, 2006). Finally, community and scientific advisory committees were adopted in order to gain feedback throughout program development.

Online Learning Modules

The conceptual framework for the training program was based on the DEC Recommended Practices (RPs) in Early Intervention and Early Childhood Special Education in the areas of environmental adaptations and instructional supports to support implementation of AT practices for children with disabilities (DEC, 2014). Specifically, the AT practices addressed how to: (1) incorporate the child's interest (Rogers & Dawson, 2010); (2) promote early literacy development through everyday activities (Rogers & Dawson, 2010); (3) use naturalistic strategies, such as modeling language, waiting for the child to initiate interaction, responding, expanding, and prompting when necessary (ECTA Center, 2018; Kaiser, Hancock, & Nietfeld, 2000); and (4) use a continuum of AT supports in the areas of classroom arrangement, shared reading, talking and listening, vision and hearing, and writing and drawing (Floyd et al., 2008; Milbourne & Campbell, 2007).

The curriculum was divided into six modules for teachers and four modules for parents and families, which were accessible by desktop computers, tablets, or mobile devices for ease of access. Table 1 demonstrates how each module aligned with DEC RPs to enhance each student's participation and engagement in early literacy activities. Module topics focused on developing teachers' knowledge and practices in (a) identifying each child's needs for AT to promote access to and participation in early literacy experiences (DEC RP E4), (b) modifying and adapting the child's environment to promote each child's access to and participation in early literacy experiences (DEC RP E3), and (c) planning for and providing AT supports and adaptations (DEC RP INS4; DEC, 2014). Each teacher module took approximately 20 minutes and included written information, videos, and interactive reinforcement activities.

The four corresponding parent modules mirrored the content of the teacher modules (see Table 1). They were shorter in length and took approximately 10 minutes to complete. The purpose of the parent modules was to encourage shared reading experiences between caregivers and the child at home, and to increase the likelihood of children integrating the use of AT tools and strategies across settings. See Table 2 for examples of early literacy activities using AT in the school and home. An emphasis was also placed on the developmentally appropriate use of technology and screen-time limits for this child population. To support the needs of dual language learners, the modules also highlighted the importance of continuing to build skills in a child's native (home) language.

Table 1: Step Up AT Teacher Online Learning Modules

Module	DEC RP	Components of Training Modules
1	E4	Overview of early literacy and how to consider and implement AT at school and home
2	E3	Effective classroom arrangement (engineering the classroom and environmental and visual supports)
3	INS4	Adapted books and other AT to promote shared reading
4	INS4	AT supports and strategies to support vision and hearing issues
5	INS4	AT supports to promote talking and listening
6	E4	AT supports for writing and drawing

These modules have a corresponding parent module.
(December 2014)

Table 2: Examples of Early Literacy Activities for School and Home

Module	Early Literacy Activities	AT for School or Home
1	Help children develop early literacy skills by talking, signing, playing, reading, and drawing.	AT is a tool to increase children's participation in early literacy activities. Considering AT starts with the child's interests, needs, and preferences.
2	Pair words in the book with actual objects.	Teacher pairs books about trains with a toy train during shared reading.
3	Expose children to books and make reading a special time.	Parent adapts the book *Hungry Caterpillar* with popsicle sticks so that a child with cerebral palsy can independently turn the pages in a book during a bedtime story.
4	Incorporate alphabet books and props in shared reading.	Teacher uses light colored magnetic letters on a dark surface such as a metal baking sheet to create color contrast as a visual support for a child with vision difficulties while reading *Chica Chica Boom Boom* alphabet book.
5	Read books with repeatable lines and phrases.	Parent records the story *Brown Bear* on a talking photo album while her child with autism presses the button on the talking photo album to read the repeatable line of the story.
6	Gather and organize ideas through drawing and scribbling.	A child with a fine motor delay creates an alphabet book by drawing his favorite animals using a slant board and a chubby crayon.

Maintaining cultural sensitivity was critical to the development of this project. Therefore, the team created all content and assessment tools concurrently in Spanish with culturally relevant materials fitted for the target population in the South Florida region of the United States (Kreuter, Lukwago, Bucholtz, Clark, & Sanders-Thompson, 2003). The Step Up AT team aligned the toolkit with the demands of the demographics of the region where the program was developed, and it reflected the growing population of Latino youth in the United States (Federal Interagency Forum on Child and Family Statistics, 2012). Cultural targeting strategies were utilized to create a program that would be linguistically and culturally congruent with the needs of participants (Kreuter et al., 2003). The team developed the online toolkit in English and Spanish, in an easy-to-read and accessible format to support parents and prepare teachers to adopt AT practices. The research team also sought feedback from community advisory councils, as well as parents and teachers from each implementation year to ensure that the materials were relevant to their needs.

Curating an AT Classroom Kit for Early Literacy

The foundation of the Step Up AT Project was the promotion of evidence-based AT tools that supported the early literacy development of preschool children with disabilities. The classroom kits incorporated a range of low-tech and high-tech devices such as adapted seating, visual supports, communication devices, tablets with literacy applications, materials for adapting books, and writing aids. The toolkit included low-tech AT options accessible for families with limited resources, and tools independent of electronic screens, given the "screen-time" concern for young children (NAEYC, 2012). Schools received an AT classroom kit with these select tools, listed in Table 3, and demonstration guides on how to use the AT devices in developmentally appropriate ways to support effective implementation (Dunst et al., 2012). The selected AT tools were also made available to teachers and parents through the Step Up AT Lending Library in partnership with the statewide AT services agency.

Table 3: Step Up AT Classroom Kit

AT Tool	Use
Smartphone and tablet applications	Applications supported the accessibility and development of behavior management, writing and drawing, communication, and early literacy skills (examples: ChoiceWorks®, Go Talk Now®, Starfall's ABC®, Tell About This®, and more).
Switches	Allowed for devices, toys, and apps to be activated by a press of a button (examples: Perrerro® Switch, Jelly Bean Twist®, Koosh® Switch, and adapted bubble blower).
Communication software	Software and supplies to create visual supports and communication boards (examples: Boardmaker® Software, LessonPix® software, and laminator).
Communication devices	Devices with one, two, or nine voice outputs allowed for making choices, commentating, and requesting (examples: Big Mack® Switch, iTalk 2®, Go Talk 9®).
Book stand	Held and adjusted placement of reading material for more accessibility.
Pencil grips, chubby crayons, and fabric brushes	Allowed for easier grasp for children who struggle to hold traditional writing and drawing utensils.
Page fluffers	Physical objects, such as popsicle sticks, that were affixed and extend from pages to allow for easier training.
Keyboard with extra large keys and a big trackball mouse	Adapted keyboard and mouse for those with mobility issues or visual impairments.
Cube chair	Provided further support for sitting than traditional chair.
Clock timer	Large visual support for timed tasks.

Expert Coaching to Implement the AT Toolkit

In addition to providing a platform for self-guided learning and access to AT tools, Step Up AT provided teachers direct coaching from bilingual (English and Spanish) special education professionals. This coaching facilitated intentional and systematic skill building in a naturalistic and supportive environment (Kaiser, et al., 2000). After having viewed each of the six online learning modules, teachers and teacher aides met with AT coaches as a classroom unit for face-to-face and virtual coaching sessions. During the sessions, the AT coach would introduce, model, practice, and reflect the AT early literacy strategies within the childcare center environment (Barkley, Cross, & Major, 2005; Rush & Shelden, 2011). The team tailored the coaching sessions to address participants' needs and goals in the classroom as well as specific goals dictated in the children's individualized education plans (IEP) (Rush & Shelden, 2011).

Implementation of the Step Up AT Toolkit

Step Up AT was a five-year project which included development (years 1 and 2), randomized control trial (years 3 and 4), and dissemination (year 5) phases. This article focuses on years 1 and 2 iterations of the toolkit, the lessons learned, and the adaptations made to prepare for the randomized control trial in years 3 and 4. In addition to creating the components of the Step Up AT toolkit, the research team determined the methods and desired outcomes to measure as part of the intervention's evaluation. The intention was to capture the impact of Step Up AT at the level of the individual child, the teacher-child and parent-child relationships, and the school and home environments using both quantitative and qualitative methods. The development phase of the Step Up AT Project afforded the interdisciplinary research team time to refine the implementation and evaluation methods required to create an evidence-based training program that translated AT strategies from theory into practice. Future publications will discuss a thorough explanation of the measurement tools and preliminary findings of the project.

Criteria for Participation

In the development phase (years 1 and 2), sites and participants met the following inclusion criteria. The schools (a) were required to have teachers that spoke English or Spanish; (b) served children between 35 and 60 months (i.e., three to five years old); who (c) had a current Individualized Education Program (IEP); and a (d) parent's or primary caregiver's consent for their child's participation, as well as a parent or caregiver willing to engage in the project.

There were no restrictions as to the specific type of disabilities children had to have in order to participate. The curriculum did not target students with particular disabilities because it was intentionally designed to support a broad range of abilities found in inclusive classrooms. In the first two years, the Step Up AT team implemented the intervention at inclusive Head Start and community-based voluntary pre-kindergarten (VPK) settings, and self-contained early childhood classrooms. The intention of the toolkit was to support teachers and families in various educational settings, including mainstreamed and more specialized programs given that AT has been found to benefit in all settings (Dunst et al., 2012; Satterfield, 2016).

The direct coaching component of the toolkit then addressed more individualized needs of the children in each participating classroom. By coaching to the specific needs of the students at that time, teachers were then able to practice implementing the various strategies across multiple cases. The goal was that the teachers would continuously integrate the AT strategies into their practices to meet the needs of future students with disabilities. To this point, the range of diagnosed disabilities included autism spectrum disorders, physical disabilities, developmental delays, chronic medical conditions, hearing impairments, intellectual disabilities, speech or language impairments, visual impairments, and dual sensory impairments. The majority of disabilities among students in years 1 and 2 were related to speech and language delays. The type and severity of the child's disability were self-reported by caregivers. Table 4 outlines the demographics of year 1 and 2 participants. In year 1, the children and teachers were distributed across 10 inclusion classrooms at one Head Start program, and in year 2, across six classrooms, inclusion and self-contained, at two VPK centers.

Table 4: Step Up AT Participant Demographics

Role	**Year 1 (*N* = 64)**	**Year 2 (*N* = 84)**
Head Teacher	10	6
Teacher Aid	10	10
Child	22	34
Primary Caregiver	22	34
Childcare Centers	1	2
Classroom	10	6
Ethnicity	**Year 1 – *N* (%)**	**Year 2 – *N* (%)**
Hispanic	64 (100)	61 (73)
Non-Hispanic	0	23 (27)
Child Disability (self-reported)	**Year 1 – *N* (%)**	**Year 2 – *N* (%)**
Autism Spectrum Disorder	2 (9)	10 (29)
Developmental Delay	1 (5)	7 (21)
Speech and Language Delays	10 (86)	9 (26)
Other	0	8 (24)
Severity of Disability (self-reported)	**Year 1 – *N* (%)**	**Year 2 – *N* (%)**
Severe	9 (41)	2 (6)
Moderate	12 (54)	11 (32)
Mild	1 (5)	14 (41)
Not reported	0	7 (21)

Recruitment, Enrollment and Retention

The research team engaged in ongoing community networking with those organizations that address the needs of children with disabilities and community health disparities, in order to identify and recruit inclusion-based childcare centers. During both years of the development phase, the childcare center directors and support staff identified eligible students and brokered the initial contact with both teachers and parents. A letter was sent to parents in English and Spanish on behalf of the principal investigator informing them of their child's eligibility to participate. In addition, a flyer was created to summarize project eligibility criteria, benefits, and requirements detailed for teachers and primary caregivers.

Teachers and caregivers were invited to attend orientation meetings of the Step Up AT project. If caregivers could not attend, the research team set up individual appointments to complete the informed consent process and pre-assessment surveys, and to allow participants the opportunity to seek clarification, ask questions, or have the materials read to them if necessary. In order to accommodate caregiver schedules, the research team and AT coaches made appointments early in the morning and after working hours. Childcare and refreshments were provided during all program events to increase parent participation. The coaches also offered appointments at the school for parents with limited home internet access in order to facilitate their viewing of the online learning modules.

In addition to the professional development and training, parents and teachers were offered incentives for completing the program. Teachers received the AT classroom kits with iPads® to access the Step UP AT toolkit and had the opportunity to earn Continuing Education Credit Units (CEUs) for their participation.

Parents received a gift basket of adapted books, writing supports and other low-tech AT valued at fifty dollars for their participation in the parent workshop and the completion of any required assessments. Both teachers and caregivers had access to the Step Up AT Lending Library of AT resources.

Implementation – Year 1

Year 1 of Step Up AT began in January 2017, in the middle of an academic year when the grant cycle began. In year 2, the program spanned fall and spring semesters, and has since continued to be a full academic year training. Between January and May 2017, the following components of the Step Up AT toolkit were implemented at one Head Start early childhood center: (a) four teacher and four parent online learning modules, (b) access to the AT devices and resources through the classroom kit and Step Up AT Lending Library, (c) expert training for teachers via three coaching sessions per module, and (d) one workshop for teachers on how to use Boardmaker® Share to make visual supports and one parent AT orientation workshop.

During this year, Step Up AT had one AT Coach working with the Head Start center. Because it was an inclusion program, the eligible students were distributed across 10 classrooms where each classroom unit included approximately two participating students. This meant that the AT Coach worked with ten teacher-teacher aide dyads. Due to the short amount of time available to launch the program, only four of the six teacher learning modules were developed, and only three coaching sessions were provided per module, to introduce the AT strategy, to model, and then to practice the concept. The two remaining modules were developed over the course of the academic year to be implemented in year 2. Pre-assessment data was collected in December 2016, prior to implementation of the intervention. Post-assessment data was collected and focus groups were conducted with participants at the end of the school year in May 2017.

Outcomes and Benefits from Year 1

Lessons learned from the first iteration of the Step Up AT toolkit can be grouped into three main themes: (a) standardizing the curriculum to enhance learning among teachers, (b) adapting the program for greater parent engagement, and (c) improving logistics with the participating childcare centers. Focus group discussions, observations from the research and project team, and feedback from community and scientific advisory councils determined these main themes.

Standardizing curriculum. In advance of year 2, the coaching schema was updated with formalized coaching lesson plans, fidelity checks, a complementary teacher workbook and demonstration guides on how to use the AT. These were created in response to teachers who had requested additional structure in the content delivery. The lesson plans and workbooks ensured that the toolkit was implemented with fidelity across different classrooms, schools and academic years, even with additional AT coaches. These resources were available in print and on the Step Up AT website (www.StepUpAT.com) which participating teachers and parents could access with a username and password. In addition to the standardized curriculum, fidelity checks and adherence forms provided AT coaches a method to monitor the progress of teachers, teacher aides, and parents based on a quantifiable level of engagement and participation. Furthermore, the project team incorporated an intensive workshop on how to use software, specifically Boardmaker®, to create visual supports, communication boards, and overlays for communication devices. Fidelity measures for coaches were also developed to ensure that the program was implemented as intended.

Strategies for parent engagement. This program targeted childcare centers located in underserved, low-resource communities. Barriers associated with underserved communities, although seen across all socioeconomic levels, may have interfered with overall parent participation (i.e. inflexible work schedules, transportation issues, childcare limitations, single parent households, etc.). Based on feedback and observation from year 1, the project team decided to modify the parent AT orientation workshop for year 2 to be more interactive and to facilitate hands-on practice with the AT tools and strategies. The 2-hour workshop was independent of an orientation on the program, and was offered twice per year, once in the fall and once in the spring, to accommodate schedules. Adding this workshop increased parent engagement from 14% to 41%, where parents watched at least one online module or attended one parent workshop.

To further encourage parent engagement, the project team created a “home-school connection” handout that fostered communication between teachers and parents related to the types of AT and how each child was utilizing AT in the classroom so that these practices could be translated to the home environment. Finally, AT coaches increased their use of free software to send group and individual text messages and made phone calls for more consistent communication with parents. It was determined that the parent requirements for participation needed to be more clearly presented during the consent and intake process at the onset of the program. These requirements included watching the 4 online modules, attending an orientation, attending the 2-hour AT workshop, reviewing the “home-school connection” forms, and completing all pre and post surveys for the program. Completing these requirements made parents or caregivers eligible for the Step Up AT gift basket previously described.

Improving program procedures. During the developmental phase of Step Up AT, the project team learned the necessity of ensuring that participating childcare centers have the appropriate technological resources—computers that function with software used in the AT toolkit, access to printers, and a strong wireless internet connection for an uninterrupted virtual learning experience. Furthermore, in the first year, one AT coach worked with ten classroom units; it was determined that this ratio was not feasible while implementing the full program in year 2, so fewer classrooms were enrolled with larger populations of children with disabilities.

Implementation – Year 2

During year 2 of the development phase, the Step Up AT team implemented the intervention from October 2017 through May 2018 at two VPK centers. The following components of the Step Up AT toolkit were implemented: (a) six teacher and four parent online learning modules; (b) teacher workbooks, AT demonstration guides, and access to the AT devices and resources through the classroom kit and Step Up AT Lending Library; (c) four coaching sessions per module; (d) one teacher and one parent Step Up

AT orientation; and (e) one Boardmaker® Share workshop for teachers and one 2-hour parent AT workshop.

In year 2, two AT coaches delivered the Step Up AT toolkit to six classroom units across two childcare centers. The team expanded the six teacher modules to be delivered across four weeks each, in order to offer four coaching sessions per module. The AT coach introduced a strategy and then modeled it, the teacher practiced the AT strategy, and then, one final coaching session allowed time to reflect and troubleshoot challenges teachers experienced in the integration of the AT tools and practices in the classroom. This last coaching session was established as a virtual session, utilizing the iPad® in the Step Up AT classroom kit and the teleconference software Zoom®. Pre-assessment data was collected prior to implementing the intervention in October 2017. Post-assessment data was collected and focus groups were conducted at the end of the school year in May 2018

Outcomes and Benefits from Year 2

Lessons learned from the second iteration of the Step Up AT toolkit are related to three main themes: (a) updates to the online learning system and modules, (b) adaptations to encourage further parent engagement, and (c) preparing the toolkit for dissemination so that the toolkit may reach a larger audience. Again, these were determined by focus group discussions, observations from the research and project team, and feedback from community and scientific advisory councils.

Updating the online learning system. After year 1, the community advisory council suggested that adjustments be made to the online learning modules so that they would meet accessibility criteria. Members provided insight regarding the need for high contrast colors and visuals, integrating alternative text to describe photos, as well as including voice narration throughout. These modifications were included in the 2018-19 iteration, year 3, of the online learning modules. The scientific advisory council suggested the Step Up AT team include demonstration videos to the website to further engage parents. It was also advised to create a list of Android® based applications that mirror the iOS® applications highlighted in the learning modules. These modifications were made in advance of year 3.

Strategies for parent engagement. The Step Up AT team learned that it was important to integrate the program into the already established offerings at each childcare center. During year 3 planning, if there were parent events or forms of communication already organized within the structure of the childcare center, Step Up AT looked to integrate program components with these institutional practices for long-term sustainability and adoption of practices. The team also began building partnerships with parent training and information centers who have a more established social media presence and relationships with families in the region. Parent engagement continued to increase, and in year 3, 52% of parents watched at least one module or attended one workshop.

In year 3, Step Up AT coaches started to track the fidelity of parent participation in each component of the program – attendance at workshops, completion of the online modules, interaction with the coach via email, text or the home-school connection form. Finally, the AT coaches created a plan to publish short videos for parents on the online learning system to demonstrate the use of AT in the classroom. During focus groups, parents informed the team that due to busy schedules, shorter messages with electronic links to resources might be a better form of communication with families.

Preparing for dissemination. As the program evolved, the integration of virtual coaching sessions was utilized more frequently as a way to maintain the coaching dynamic while maximizing fiscal and personnel resources. After year 2, the scientific advisory council suggested adding demonstration videos or modules to serve as supplemental strategies for children with more profound disabilities. The idea was to expand the foundational video offerings, in order to leave more time for the AT coaches to provide targeted coaching in the classroom. Finally, booster sessions for previously participating centers were implemented to provide additional support as teachers continued to integrate AT strategies in the classroom.

Conclusion

Promoting inclusion and enhancing utilization of AT to support early literacy for preschoolers with disabilities should be an encouraged standard of practice in early childhood settings. Step Up AT provided extended training and coaching for teachers to learn and integrate AT best practices into daily classroom routines. This program utilized a multi-pronged approach to deliver professional development through virtual and in-person modalities. Specifically, it did this by providing teachers and caregivers a toolkit consisting of (a) online learning modules, (b) access to AT tools and resources, as well as (c) in-person and virtual coaching, while addressing the diverse language and cultural needs of South Florida.

During the development phase of the project, the interdisciplinary team implemented two iterations of the Step Up AT toolkit. A third iteration would be evaluated in a future wait-listed randomized-control study. Between years 1 and 2, and years 2 and 3, the project team worked to minimize barriers to parent and teacher participation by standardizing procedures, curriculum and fidelity measures, as well as modifying the delivery of workshops and coaching sessions. The accessibility features of the online modules and the use of virtual coaching were also improved. This development phase of Step Up AT allowed the team to formulate a well-designed professional development program that can be replicated for future evaluation and dissemination.

References

Baker, F. S. (2014). Engaging in play through assistive technology: Closing gaps in research and practice for infants and toddlers with disabilities. In DaCosta, B. & Seok, S. *Assistive technology research, practice, and theory* (pp. 207-222). Hershey, PA: IGI Global.

Barkley, E. F., Cross, K. P., & Major, C. H. (2005). *Collaborative learning techniques: A handbook for college faculty.* San Francisco: John Wiley & Sons.

Beard, L. A., Bowden Carpenter, L. A., & Johnston, L. B. (2011). *Assistive technology: Access for all* *students* (2nd ed.). Boston, MA: Pearson.

Burne, B., Knafelc, V., Melonis, M., & Heyn. P. (2011). The use and application of assistive technology to promote literacy in early childhood: A systematic review. *Disability and Rehabilitation: Assistive Technology, 6*, 207-213. doi:10.3109/17483107.2010.522684

Cardon, T. A., Wilcox, M. J., & Campbell, P. H. (2011). Caregiver perspectives about assistive technology use with their young children with autism spectrum disorders. *Infants & Young Children, 24*, 153-173. Retrieved from https://www.learntechlib.org/p/50621/

Diamond, K. E., & Powell, D. R. (2011). An iterative approach to the development of a professional development intervention for Head Start teachers. *Journal of Early Intervention, 33*, 75-93. doi: 10.1177/1053815111400416

Division for Early Childhood (DEC). (2014). *DEC recommended practices in early intervention/early childhood special education 2014.* Retrieved from http://www.dec-sped.org/recommendedpractices on March 31, 2016.

Dunst, C. J., Bruder, M. B., & Hamby, D. W. (2015). Meta-synthesis of in-service professional development research: Features associated with positive educator and student outcomes. *Educational Research Reviews, 10*, 1731-1744. doi: 10.5897/ERR2015.2306.

Dunst, C. J., Trivette, C. M., & Hamby, D. W. (2012). Assistive technology and the communication and literacy development of young children with disabilities. *Center for Early Literacy Learning, 5*(7), 1-13. Retrieved from http://www.earlyliteracylearning.org/cellreviews/cellreviews_v5_n7.pdf

Early Childhood Technical Assistance (ECTA) Center. (2018). *Naturalistic instruction practices.* Retrieved from http://ectacenter.org/decrp.

Federal Interagency Forum on Child and Family Statistics. (2012). *America's children in brief: Key national indicators of well-being.* Washington, DC: US Government Printing Office.

Floyd, K. K., Smith Canter, L. L., & Judge, S. A. (2008). Assistive technology and emergent literacy for preschoolers: A literature review. *Assistive Technology Outcomes and Benefits, 5*(1), 92-102. Retrieved from https://eric.ed.gov/?id=EJ884370

Friedman, M., Woods, J., & Salisbury, C. (2012). Caregiver coaching strategies for early intervention providers: Moving toward operational definitions. *Infants & Young Children, 25*, 62-82. doi: 10.1097/IYC.0b013e31823d8f12

Hemmingsson, H., Lidstrom, H., & Nygard, L. (2009). Use of assistive technology devices in mainstream schools: Students' perspective. American Journal of Occupational Therapy, 63, 463-472. Retrieved from https://pdfs.semanticscholar.org/1e17/d9909229b7398632d05924707535875567af.pdf

Hill, D. A., & Flores, M. M. (2014). Comparing the picture exchange communication system and the iPad™ for communication of students with autism spectrum disorder and developmental delay. *TechTrends*, *58*(3), 45-53. doi: 10.1007/s11528-014-0751-8

Kaiser, A.P., Hancock, T. B., & Nietfeld, J. P. (2000). The effects of parent-implemented enhanced milieu teaching on the social communication of children who have autism. *Early Education and Development*, *11*, 423-446. doi: 10.1207/s15566935eed1104_4

Kaplan, M., & Mead, S. (2017). The best teachers for our littlest learners: Lessons from Head Start's last decade. Bellwether Education Partners. Retrieved from https://bellwethereducation.org/sites/default/files/Bellwether_HeadStartWorkforce.pdf

Karlsson, P., Johnston, C., & Barker, K. (2017). Influences on students' assistive technology use at school: The views of classroom teachers, allied health professionals, students with cerebral palsy and their parents. *Disability and Rehabilitation Assistive Technology*, 1-9. doi: 10.1080/17483107.2017.1373307

Kreuter, M. W., Lukwago, S. N., Bucholtz, D. C., Clark, E. M., & Sanders-Thompson, V. (2003). Achieving cultural appropriateness in health promotion programs: Targeted and tailored approaches. *Health Education and Behavior*, *30*, 133-146. doi: 10.1177/1090198102251021

Light, J., & McNaughton, D. (2012). Supporting the communication, language, and literacy development of children with complex communication needs: State of the science and future research priorities. *Assistive Technology*, *24*(1), 34-44. doi: 10.1080/10400435.2011.648717

McCray, E. D., Brownell, M. T., & Lignugaris, B. (2014). *Handbook of research on special education teacher preparation*. New York, NY: Routledge.

Milbourne, S. A., & Campbell, P. H. (2007). *CARA's kit: Creating adaptations for routines and activities*. Child and Family Studies Research Programs, Thomas Jefferson University.

National Association for the Education of Young Children (NAEYC) & the Fred Rogers Center for Early Learning and Children's Media. (2012). Technology and interactive media as tools in early childhood programs serving children from birth through age 8. Retrieved from https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/topics/PS_technology_WEB.pdf

National Institute for Early Education Research (NIEER). (2006). Early literacy: Policy and practice in the preschool years (Preschool Policy Brief, 10). New Brunswick, NJ: Strickland, D., & Riley-Ayers, S. Retrieved from http://nieer.org/wp-content/uploads/2016/08/10.pdf

National Institute for Early Education Research (NIEER). (2011). Degrees in context: Asking the right questions about preparing skilled and effective teachers of young children (Preschool Policy Brief, 22). New Brunswick, NJ: Whitebrook, M., & Ryan, S. Retrieved from http://nieer.org/wp-content/uploads/2016/08/23-2.pdf

National Institute for Literacy. (2009). Early beginnings: Early literacy knowledge and instruction. Washington, DC. Retrieved from https://www.nichd.nih.gov/publications/pubs/documents/NELPEarlyBeginnings09.pdf

Neuman, S. B., & Cunningham, L. (2009). The impact of professional development and coaching on early language and literacy instructional practices. *American Educational Research Journal*, *46*, 532-566. doi: 10.3102/0002831208328088

Nikolopoulou, K., & Gialamas, V. (2015). ICT and play in preschool: Early childhood teachers' beliefs and confidence. *International Journal of Early Years Education*, *23*, 409-425. doi: 10.1080/09669760.2015.1078727

Parette, H. P., & Stoner, J. B. (2008). Benefits of assistive technology user groups for early childhood education professionals. *Early Childhood Education Journal*, *35*, 313-319. doi: 10.1007/s10643-007-0211-6

Rogers, S. J., & Dawson, G. (2010). *Early Start Denver model for young children with autism: Promoting language, learning, and engagement.* New York, NY: Guilford Press.

Rush, D., & Shelden, M. (2011). *The early childhood coaching handbook*. Baltimore, MD: Paul H. Brookes.

Satterfield, B. (2016). History of assistive technology outcomes in education. *Assistive Technology Outcomes and Benefits*, *10*(1), 1-18. Retrieved from https://www.atia.org/wp-content/uploads/2016/11/ATOBN1V10_ART1.pdf

Simpson, C. G., McBride, R., Spencer, V. G., Lowdermilk, J., & Lynch, S. (2009). Assistive technology: Supporting learners in inclusive classrooms. *Kappa Delta Pi Record*, *45*, 172-175.

Smith, S. B. & Smith, J. S. (2004). Technology integration solutions: Preservice student interns as mentors. *Assistive Technology Outcomes and Benefits*, *1*(1), 42-56. Retrieved from https://www.atia.org/wp-content/uploads/2015/10/ATOBV3N1.pdf

Stanger, C., Mims, P., Wood, L., & Ahlgrim-Delzell, L. (2016). Supporting literacy achievement for students with intellectual disability and autism through curricular programs that incorporate assistive technology. *Assistive Technology Outcomes and Benefits*, *10*(1), 51-73. Retrieved from https://www.atia.org/wp-content/uploads/2016/11/ATOBN1V10_ART4.pdf

Teale, W. H., Hoffman, J., & Paciga, K. (2014). What do children need to succeed in early literacy—and beyond? In K. Goodman, R. Calfee, & Y. Goodman (Eds.), *Whose knowledge counts in government literacy policies? Why expertise matters* (pp. 179-186). New York: Routledge.

United States Census Bureau. (2017). QuickFacts: Miami-Dade County, Florida; Broward County, Florida; Florida. Retrieved from https://www.census.gov/quickfacts/fact/table/miamidadecountyflorida,browardcountyflorida,fl#

U.S. Department of Education. (2015). 37th Annual report to Congress on the implementation of the Individuals with Education Disabilities Act (Volume I). Washington D.C. Retrieved from http://www2.ed.gov/about/reports/annual/osep/2015/parts-b-c/index.html#download

Wilcox, M. J., Dugan, L. M., Campbell, P. H., & Guimond, A. (2006). Recommended practices and parent perspectives regarding AT use in early intervention. *Journal of Special Education Technology*, *12*(4), 7-16.

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 52-76
 ISSN 1938-7261
Available online: www.atia.org/atob

Mastery of Assistive Technology in High School and Postsecondary Performance

Ben Satterfield, Ed.D.

Center for Inclusive Design and Innovation
Georgia Institute of Technology

Corresponding Author
Dr. Ben Satterfield
Center for Inclusive Design and Innovation
512 Means Street
Suite 250
Atlanta, GA 30318
Phone: (404) 618-3414
Email: rsatterfield8@gatech.edu

Abstract

A survey of 47 students with high incidence disabilities in the university system in Georgia who received assistive technology (AT) supports was conducted to discover: (a) what percentage of students came to postsecondary education comfortable with assistive technology, and (b) how does the success of students who come prepared to use AT compare to that of students who come and are not prepared to use AT? Performance (measured by grade-point average) in high school was compared to that achieved during the first year of college. Anecdotal comments by students confirm the survey's findings that students who have become comfortable using AT before coming to college have a greater likelihood, but no guarantee, of success in college.

Keywords: assistive technology, disability, transition, postsecondary education, higher education

Introduction

The Center for Inclusive Design and Innovation (CIDI (formerly known as AMAC)) is part of the College of Design at the Georgia Institute of Technology. CIDI serves the entire University System of Georgia as an accessible educational materials center, providing textbooks in alternative format (e-Text and Braille) and classroom supports such as real-time closed captioning for students in college classrooms.

The team at CIDI had observed that assistive technology (AT) was becoming a staple tool that students with high-incidence disabilities (such as learning disabilities, ADHD, etc.) were using in postsecondary settings in Georgia (N. Sinclair, personal communication, May 23, 2018). Students who qualify have access to textbooks in electronic format through CIDI. Students use computer software and tablet-based apps to help them read their textbooks and enhance comprehension. CIDI provides a help-desk team to support students who are using these services.

The help-desk team at CIDI reported frequent encounters with students who were struggling with assignments and who called in for assistance with the AT which they had chosen. As the team attempted to help, they noticed that students who had little familiarity with AT were struggling to both learn to use their AT and to keep up with their assignments. It soon became a working assumption that students who learned to use these AT tools while still in high school would have a distinct advantage over students who came to college without having had experience with these tools (N. Sinclair, personal communication, May 23, 2018). However, the team found little evidence in the research literature to confirm this assumption. They sought to discover whether there was any relationship between student mastery of AT in high school and their performance at the postsecondary level.

Target Audience and Relevance

Students with high-incidence disabilities are attending postsecondary institutions in increasing numbers (Francis, Duke, Bringham, & Demetro, 2018; Hansen & Dawson, 2019). However, only 20% of college students with disabilities successfully graduate from 4-year institutions (Grogan, 2015). Transition to postsecondary education is frequently difficult for students with disabilities as they often fail to develop the necessary proficiencies in high school that are vital to success at the next level (Francis, Duke, Bringham, & Demetro, 2018). Hall (2016) suggests that students with high-incidence disabilities who persevere in college grasp the importance of AT and its value in helping them complete classwork assignments.

This article addresses the impact that learning to use AT while in high school might have on student success in postsecondary settings. The early research cited speaks specifically to the impact of AT upon outcomes such as graduation from high school, future independence, and positive work outcomes for students with high-incidence disabilities. Our research illuminates further the value of early availability of AT for students with high-incidence disabilities. For these reasons, teachers and administrators in K-12 settings will find this article valuable and informative relative to their decision making regarding the integration of AT in their local setting. Parents and advocates will find this paper instructive as they seek the best for their charges. Researchers will find the article helpful in its summary of research on AT and transition and for its identification of areas that merit deeper and more detailed study.

Literature Review

For the past three decades, the field of AT has held to an abiding assumption that properly adapted technology can have a beneficial impact upon individuals with high-incidence disabilities. In its early days, the AT field was largely a “boutique” enterprise (Colker, 2002). Company resources went into the development of solutions that addressed the needs of individuals with visibly challenging disabilities (Edyburn, 2000). Positive results were noted. Yet early on little research was devoted to the effects of AT use by students with “mild” disabilities (Behrmann, 1994; Edyburn, 1996, Bryant, Bryant, & Raskind, 1998; Raskind, Higgins, Slaff, & Shaw, 1998).

Nevertheless, the assumption that AT did have a positive impact was expressed in federal law in the Assistive Technology Act of 1988 (P.L. 105-394), which defined assistive technology as “…any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities.” (29 U.S.C. Sec 2202(2)). The language in the act went on to stipulate that:

> *“Substantial progress has been made in the development of assistive technology devices, including adaptations to existing devices that facilitate activities of daily living, that significantly benefit individuals with disabilities of all ages.”*

Despite broad acceptance and consensus in this regard, a research base providing evidence to support this assumption was yet to emerge.

Emergence of Research

As the AT field has evolved into an industry, studies done in this area have suggested that use of AT in school promotes independence, self-confidence, and productivity among students with disabilities. (Craddock, 2006; Englert, Manalo, & Zhao, 2004; Fichten, Asuncion, Barile, Fossey, & Robillard, 2001; Higgins & Raskind, 2004; Jutai, Rigby, Ryan, & Stickel, 2000; Macarthur, 1999; Mazzotti, Test, Wood, & Richter, 2010; Mechling, 2007; Riffel et al., 2005; Wehmeyer et al., 2006).

Other studies have pointed to improved academic performance of students using AT in K-12 settings (Brackenreed, 2008; Geary, 2004; Hasselbring & Glaser, 2000; Hetzroni & Shrieber, 2004; MacArthur & Cavalier, 2004; MacArthur, 2009; Mazzotti et al., 2010; Raskind & Higgins, 1998; 1999). Other studies have noted the association between AT use in high school and the greater likelihood of enrollment in postsecondary educational opportunities (Anderson-Inman et al., 1999; Mitchem et al., 2007; Stodden, Conway, & Chang, 2003), and between AT use in high school and positive employment outcomes (Gamble, Dowler, & Orslene, 2006; Luecking & Certo, 2003; Wehmeyer et al., 2006). Still other studies have linked AT use in high school with better outcomes with regard to the transition to independent living

(Anderson-Inman et al., 1999; Mazzotti et al., 2010; Mull & Sitlington, 2003; Riffel et al., 2005; Sharpe, Johnson, Izzo, & Murray, 2005).

Students with High-Incidence Disabilities

There is limited research with regard to AT use by students with high-incidence disabilities and postsecondary education (Sharpe, et.al., 2005; Alper & Raharinirina, 2006; Floyd, 2012). This group of students has been defined as students with learning disabilities, emotional-behavior disorders, mild intellectual disabilities, attention deficit/hyperactivity disorder (ADHD), and sometimes high-functioning autism spectrum disorder (Murray & Pianta, 2007). Students with high-incidence disabilities represent about 70% of all students with disabilities (Aud et al., 2011). This group is attending college in ever increasing numbers (Francis, Duke, Bringham, & Demetro, 2018).

For this group of students as a whole, the literature suggests that there have historically been several difficulties with transition. Among students with high-incidence disabilities there are historically low levels of enrollment in postsecondary education (Garza, 2005), high rates of unemployment (Curtis, Rabren & Reilly, 2009), and lower rates of independent living as compared to their typical peers (Wagner et.al., 2005). This particular group of students appears to face challenges associated with literacy (i.e., reading and writing) as well as mathematics (Murray, 2002). Even though there are AT products that can help address these challenges, AT use among these students has been limited (Kaye, Yeager, & Reed, 2008; Malcolm & Roll, 2019; Parette & Scherer, 2004; Woodward & Reith, 1997).

The reasons for this have included the cost of technology as well as how stigmatized the AT made the students feel (Parette & Scherer, 2004). Students with “invisible disabilities” received accommodation less frequently than students with more obvious disabilities (Lightner, Vaughan, Schulte, & Trice, 2012) and were less likely to self-identify as an individual with a disability to qualify for AT as an accommodation (Newman & Madaus, 2015; Malcolm & Roll, 2019). Other problems associated with AT use for students with special education needs include: availability of financial resources for family and school, lack of knowledge about AT, and a tendency toward abandonment of the technology (Kaye et al., 2008; LaPlante, Hendershot, & Moss, 1992; Phillips & Zhao, 1993; Woodward & Reith, 1997; Ofiesh, Rice, Long, Merchant, & Gajar, 2002; Parette & Scherer, 2004).

Specific Features: Inconclusive Results

Some of the most promising and substantive studies pointed out how AT might be particularly helpful for students with high-incidence disabilities who struggled with reading and writing. Lindstrom (2007) as well as Wolfe and Lee (2007) observed an increase in the frequency with which students with learning disabilities were receiving assignments and text materials in digital form at both K-12 and postsecondary level. Ostensibly this was for the purpose of using AT to aid in reading and comprehension.

Raskind and Higgins (1995) had illustrated how tools that employed speech synthesis could be helpful for students with reading difficulties in proofreading. Elkind, Black and Murray (1996), Raskind and Higgins (1998), Perelmutter, McGregor, and Gordon (2017), as well as Wood, Moxley, Tighe and Wagner

(2017) pointed to indications that text-to-speech, supported by optical character recognition (OCR), could enhance reading speed and comprehension. Stodden and Roberts (2005) suggested that speech recognition could be used to aid students who struggled with handwriting and organization of writing assignments. Perelmutter, McGregor, and Gordon (2017) also found positive effects with AT used for word processing by students with high-incidence disabilities. However, O' Neill et al. (2012) found that AT as an accommodation in testing was not as high a predictor of graduation as other accommodations.

Ultimately, these studies that have pointed to positive impacts of AT use upon students with high-incidence disabilities often lacked the size or methodology to be able to produce conclusive findings regarding outcomes of AT use (Anttila, Samuelsson, Salminen, & Brandt, 2012; Edyburn, 2013). Overall, research on AT use by students with high-incidence disabilities suggests that not all AT products produce the same level of results (Holmes & Silvestri, 2012 and Lewindoski, Wood & Miller, 2016).

National Longitudinal Transition Study

The National Longitudinal Transition Study (NLTS2, 2012) provided an extensive look at how AT factored into the transition of students with disabilities to postsecondary life. The study was conducted over a 10-year period from 2000 to 2010 and included over 305,000 students with disabilities as they completed high school and moved on to work or school or whatever was next for them. Information was collected from students, families and educators about the outcomes for these students in the areas of postsecondary education, work, and independent living (NLTS2, 2012).

The National Longitudinal Transition Study (2012) indicated that a small proportion of students with disabilities actually used AT while in high school (Bouck, 2016). However, students with low-incidence disabilities were reported to use AT in high school at a higher rate than students with high-incidence disabilities. In fact, only 7.8% of students with high-incidence disabilities reported receiving AT while in high school. The most frequently recommended AT for these students was a calculator – followed (distantly) by laptop and audible books (NLTS2, 2012).

Nevertheless, students with high-incidence disabilities who had received AT in high school were found to have more positive outcomes in terms of a paid job, wages, and participation in postsecondary education (Bouck, Maeda, & Flanagan, 2012). According to the National Longitudinal Transition Study (NLTS2, 2012), 99.8% of the students who received AT in high school graduated whereas only 79.6% of those who did not receive AT graduated. Among students who received AT in high school, 80.9% went on to attend a post-secondary institution, but only 40.1% of students who did not receive AT did so. It was also noted that 80% of those students who received AT in high school held a paying job after high school. Only 50.8% of those in this survey who did not receive AT in high school had a paying job.

Since NLTS2

Since the Longitudinal Study ended in 2010, two subsequent developments appear to have impacted the use of AT in K-12 settings. The first is the availability to schools of American Recovery and Reinvestment

Act (ARRA) funds. These funds were made available by the Department of Education in 2008 with the expectation that local districts would invest in tools and strategies, including AT, that would strengthen and transform their instruction of students with disabilities (Naik, Yorkman, & Casserly, 2010). Second was the emergence of consumer technology platforms such as the Apple iPad. Apps that provided AT supports followed quickly. Some of these tools have become part of a Universal Design for Learning approach at the local level. Some school districts have launched “one-to-one computing” and “bring-your-own technology” initiatives (Sennott & Bowker, 2009).

Together, these developments have opened the door for an increase in the use of technology for reading and writing. We have observed that screen reading software (text-to-speech) and electronic dictionaries have been more widely used to help students with reading. Speech recognition (speech-to-text), talking word processors, talking spell-checkers, word prediction, and digital graphic organizers are tools that have come into greater use to help students with writing. Our experience and observations in the field have gathered that there is a general impression that AT is more commonly available in K-12 schools than in the past and that AT use is becoming more widespread. It would be valuable to know whether AT is becoming a more regular accommodation for students with disabilities. If so, it would be important to discover whether students with disabilities are developing a level of mastery over this technology and whether the technology is making a difference in academic performance.

The Question of Mastery

Poudel (2014) explored the question of competence or mastery of AT, suggesting that a sense of confidence comes as the student attains a comfort level with the AT tools they use. Deci and Ryan (2000) have suggested that in our social and physical dimensions, as people encounter and wrestle with the challenges we face, we develop competence and mastery. This process involves the discovery of the actions that lead to success and the development of skills to perform those actions. As we build patterns of action that result in success, the positive feedback we experience reinforces our intrinsic motivation – particularly as we build successful patterns independently. Rotter (1966) posited that, as the locus of control over a skill or an activity moves from external to internal, individuals demonstrate greater evidence of achievement. Could it be that students with high-incidence disabilities who master AT while in high school have developed skills and positive patterns of action that lead to success at the postsecondary level?

Method

In order to examine this assumption that students who have learned to use AT tools while still in high school may have a distinct advantage over students who come to college without AT experience, and to gain insight into the use of AT by college students, 1570 students (who have made use of the CIDI services since 2014) were invited to take part in a survey to determine the following: (a) What percentage of students with disabilities who are referred to CIDI are coming prepared to use AT? (b) How successful are these students in college? (c) How does the success of students who come prepared to use AT compare to that of students who are not prepared to use AT? (d) Have the AT services provided by CIDI

(AMAC) been effective and helpful to these students?

Participants

Participants in this project were drawn from a list of students who were referred to CIDI by their local college Office of Disability Services and who received classroom materials in alternative media. These participants were located primarily in the state of Georgia, but included a few students who reside in other states. Of the students invited, 47 students with high-incidence disabilities completed the survey in sufficient enough detail that their replies could be included in this research.

The participants included both males and females, and ranged in ages from 19 to 25. Participants represented a broad range of ethnic backgrounds including: African-American (20%), Asian (2.5%), Caucasian (72%), and Hispanic (5.5%). The group included individuals with learning disabilities such as dyslexia, dysgraphia, etc. (66%), ADHD (19%), autism spectrum disorder (6%), and other (23%). Some identified with more than one disability area.

Instruments and Data Analysis

The study employed a survey that was conducted online and employed a web-based survey tool (Qualtrics) to collect responses. The survey consisted of 27 questions. It was divided into three parts: (a) high school experiences, (b) postsecondary experiences, and (c) personal reflections on use of AT. The questions were in one of 3 forms: Likert Scale with five choices, check-off lists, and short-answer. The survey is included in the Appendix.

For the purposes of this study, for the definition of competence or “mastery” we selected the phrase “comfortable using AT” because it connotes the internalization of control and a level of confidence with the tool. We applied this phrase when we asked the participants in this study about their competence and confidence using AT.

Qualtrics software (2019) was used to collect data and to conduct preliminary analysis of participant surveys. The chi-square calculations and other analysis were done using Microsoft Excel (2007).

Results

Participants in the survey were asked to characterize their level of comfort with AT when they came to the postsecondary level. Over one-half of the respondents (55.1%) said they were very comfortable or confident with AT prior to college. There were 44.9% who said they were uncomfortable or unsure of their ability to use AT.

In order to operationalize the impact of AT on postsecondary academic performance, participants were asked to disclose their grade-point average (GPA) upon finishing high school and their GPA at the end of their freshman year of college. These GPAs were compared to reflect the academic performance of each participant as they transitioned from secondary to postsecondary settings. We looked first at the change in GPA (up or down) of students who said they were comfortable with AT and then at participants who said they were unsure or not comfortable with AT.

Among all students who were comfortable with AT, GPAs went up or stayed the same for 80.77% of the respondents. Grades went down for 19.23% of those who came comfortable with AT (see Table 1). For participants who were unsure or not comfortable with AT, 47.62% reported that GPA stayed the same or went up in their freshman year. Here, 52.38% of those who said they were unsure or uncomfortable with AT reported that their grades went down in their first year in postsecondary education (see Table 1).

Table 1: Change in GPA for Students with High-Incidence Disabilities

	GPA Up/No Change	GPA Down
Comfortable with AT	80.77%	19.23%
Uncomfortable with AT	47.62%	52.38%

We used the chi-square test for independence to establish the significance of this calculation. The chi-square statistic is 5.6957. The critical value at the 0.05 level is 3.8410. Since the chi-square statistic is greater than the critical value, we must reject the null hypothesis that AT mastery and performance at postsecondary level are independent.

When asked if they believed that AT made a difference, the great majority of respondents said that AT probably or definitely made a difference (See Table 2). No participants said that they did not believe that AT made any difference.

Table 2: Did AT Make a Difference? (Students with High-Incidence Disabilities)

Definitely	64%
Probably	17%
Maybe	10%
Not	0%
No Answer	8%

Participant Comments

Participants were given the opportunity to comment on the impact AT made on their postsecondary performance. Their comments suggest that AT was important to their success.

One student said,

> *“My grades and GPA has [sic] gone up dramatically with the [AT] I have been given.”*

Another student remarked,

> *“I … need all the help [I can get]. I cannot write — was never taught how to use tech in High School. It helped make learning in college easier to understand… Typing is excruciatingly painful for me; I don't think I would've been able to write the required essays in my intro*

humanities courses without the use of speech recognition technology. Now I use assistive technology and my grades have improved."

Another student observed:

"I feel [AT] should be more readily available to students from the time they are diagnosed through their entire education in order to better enable them for a successful education and learning environment."

How Was AT Mastered?

When asked about the ways that participants learned to master the AT they used (see Table 3), most said that they were self-taught to some degree (68.09%). Others reported that they were aided by their Office of Disability Services (44.68%) and by CIDI (AMAC) Accessibility service (19.15%). Some were helped by viewing tutorials on a product website (14.89%) or by a friend or peer tutor (12.77%). A smaller percentage attended a formal training (4.26%).

Table 3: How Participants Learned to Use Their AT

Self-taught	68.09%
Support from the Office of Disability Services	44.68%
Support directly from AMAC (CIDI)	19.15%
Viewed tutorials on product website	14.89%
Friend or peer showed me how to use it	12.77%
Attended a training	4.26%

What Kinds of AT?

Students were asked to indicate the kinds of AT to which they had access in high school (see Table 4). The most commonly available AT were a calculator (76.06%) and a spell checker (38.30%). Screen reader (25.53%) and audible text (23.40%) were the next most common. It is worth observing that 23.04% of students in this student reported they did not use AT in high school.

Table 4: Kinds of AT in High School

	Available	**Used**
Calculator	76.60%	65.96%
Spell checker	38.30%	29.79%
Screen reader (text-to-speech software)	25.53%	12.77%
Audible textbooks	23.40%	21.28%
Audio recorder	17.02%	12.77%
Magnification/Enlargement tools	8.51%	6.38%
Word prediction	6.38%	8.51%
Graphic organizer	6.38%	4.26%
Speech recognition (speech-to-text software)	12.77%	8.51%
Electronic dictionary	10.64%	6.38%
Talking word processor	2.13%	2.13%
Other	1.13%	0.00%
None of these	14.89%	23.40%

Regarding AT use at the postsecondary level (as compared to AT use in high school), participants in this study reported greater use of auditory support for reading tools (audible books and text-to-speech). Slightly more common use of audio recorders for capturing classroom lectures and electronic dictionaries for vocabulary support were also noted (see Table 4).

Discussion

The results of the CIDI/AMAC Survey appear to confirm many aspects of previous research regarding use of AT in high school. While this study's results suggest a positive impact from mastery of AT in high school upon performance at the postsecondary level, the findings do not guarantee this. This is consistent with Bouck, Maeda, and Flanagan's (2012) analysis of the National Longitudinal Study. While the CIDI/AMAC survey results appear to confirm the findings of the National Longitudinal Study (NLTS2) that calculators remain a highly recommended K-12 accommodation for students with disabilities, this study suggests that a broad range of AT is now more commonly available and is being used by more students with high-incidence disabilities. Whereas Bouck et.al. (2012) found that only 7.8% of students with high-incidence disabilities were being provided with AT, this study found that 76.6% of students in this study used AT in high school. While 23.4% of students not using AT is still high and is not optimal, this study's findings would suggest that progress is being made in providing AT to students with high-incidence disabilities in high school.

Poudel (2014) observed that the AT items provided to students with high-incidence disabilities often suggested a practice of generic assignment of AT based on disability label and not based on individual need. This study did not examine the basis on which AT is provided to students with high-incidence disabilities. It seems reasonable to assert that use of an evidence-based model, such as the SETT Framework (Zabala, 1995), that takes into consideration the strengths and weaknesses of the individual, would be essential.

Perhaps the fact that many students who do use AT continue to be self-taught (68.09%) is reflective of an "andragogical" approach to problem solving (McGrath, 2009). Yet researchers continue to observe this phenomenon despite the growing body of supports made available online and via supporting agencies (Rashid & Asghar, 2016). However, it is also likely that this is an indication of the need for better planning and support for implementation of AT. Clearly, simply providing AT is not sufficient.

It is somewhat encouraging to observe that the survey results suggest that over half (55.1%) of participating students are coming to college having become comfortable with AT in high school. This provides encouraging evidence that students with high-incidence disabilities are receiving AT more frequently. Further, 1-to-1 computing and "Bring Your Own Technology" (BYOT) initiatives as well as the prevalence of consumer–based platforms for AT may be reducing the perception in students' minds that use of AT may set them apart or cast them in a negative light. Nevertheless, the study also reveals that a sizeable number (23.4%) used no AT while in high school, suggesting that work remains to be done on providing access to AT.

Conclusions and Future Study

The success of students with high-incidence disabilities who have mastered AT in high school is noteworthy. The fact that 80.77% of the students who came to postsecondary education having a comfort level with their AT maintained or improved their high school GPA stands in contrast to the finding that only 47.62% of students who lacked AT mastery maintained or improved their GPA during their freshman year. Only 19.23% of the students mastering AT in high school had GPAs that were lower than their high school GPAs, as compared with 52.38% of the participants who came without mastery of AT. These findings do not suggest that mastery of AT is a guarantee of success at the next level. They do, however, reinforce the insight that the postsecondary level represents significant challenges for students with high-incidence disabilities and that becoming equipped and prepared for what they will face in the new environment is important.

It seems clear that in order to be effective, AT must be appropriate for the individual using it. Mastery implies taking ownership and establishing competence and confidence with the tool. Yet, this study has not fully addressed the question of what the concept of AT mastery represents. One aspect that might be worthy of further investigation would be the degree to which a student's confidence (or comfort level) with AT impacts the level of their self-advocacy. It is clear that at the postsecondary level, it is up to the student to self-identify as an individual with a disability and to advocate for the accommodations that help them (Garrison-Wade, 2012; Getzel & Thoma, 2008). Our experience has been that, in order to master a tool, the individual must develop their own strategies for its use. These are likely to be individualized as each student establishes a pattern for using the features of the tool that are personally most helpful. We have observed that two individuals may use the exact same set of tools, yet use them in different ways to accomplish the same tasks.

Undoubtedly, there are other elements that must be considered in any list of factors contributing to success. Nevertheless, mastery of AT appears to enhance the chances for success of students with disabilities.

Effectiveness of CIDI/AMAC and Office of Disability Services (ODS)

As previously observed, the findings of earlier research suggested that many students were self-taught when it came to their mastery of AT. This finding was echoed in this survey. The next most frequent source of AT support and training reported was that provided by the local campus ODS (44.68%). The fact that support from the CIDI/AMAC Accessibility Lab (19.15%) was ranked third most frequently employed could be understated. Many of the services provided by CIDI/AMAC are delivered by the local ODS as a seamless pass-through process, and might not be observed by the student as coming from CIDI. The number of respondents who actually identified CIDI/AMAC probably relates to the help-desk support and training provided to students directly. While the extent to which students received services and support for AT use is sizeable, there remains room for CIDI and the local ODS teams to expand their influence and impact.

Limitations

This study was conducted with survey data from 47 students who exercised the option to take part in this project. Participants volunteered information about their experiences that was not validated through observation, nor were grade-point averages confirmed with the appropriate educational institutions. No attempt was made to identify what other accommodations might have been in place which could have contributed to the results reported. Given these limitations, care should be taken when attempting to apply or generalize the results of this study.

Outcomes and Benefits

This study appears to point to an advantage that mastery of AT while in high school gives a student with a high-incidence disability as they transition to a postsecondary setting. If this is true, then several benefits should follow.

Students still in K-12 settings can take heart that investing time and effort learning to use the AT tools that help them with reading, writing, and math will pay dividends as they complete high school and also when they transition to postsecondary opportunities. Having mastery over AT can bolster their confidence and encourage them to believe that they can succeed at that next level. If teachers and school administrators in K-12 recognize and apply the outcomes from this study, and seek to appropriately apply AT in their local setting for students with high-incidence disabilities, this should ultimately be reflected in higher graduation rates and better outcomes as their students transition to college or technical school.

Parents and advocates can leverage this study and the other research cited here that points to positive outcomes from AT use, to call for the early exploration and adoption of AT solutions for their charges. By introducing AT early on, students stand a better chance of staying with their classroom peers with regard to the understanding of content while they address reading and writing challenges. Parents and advocates can be encouraged that, rather than experience frustration and failure, their students can experience success and grow in confidence in their ability to use AT to help them overcome challenges.

Researchers will find that this study generally affirms the findings of studies that have preceded it. However, there are many aspects of this study which suggest the need for further research, such as the impact of mastery of AT upon other outcomes such as self-confidence and self-advocacy. The indication that mastery of AT can affect performance in postsecondary educational settings raises the question as to whether there might be a similar impact for students with high-incidence disabilities upon employment. This study has illuminated the need for individualized AT recommendations in high school as opposed to generic prescriptions based on disability (i.e. if a student has a learning disability they are provided with a calculator). Furthermore, students need individualized support and training in order to effectively use the AT they receive. Mastery will require use of an AT tool over an extended period of time. A more systematic approach to the recommendation and implementation of AT is indicated.

The need for further research on what is involved in the concept of mastery of AT has been identified here. Deeper exploration of this concept should yield useful insights into how schools can prepare students with high-incidence disabilities for greater success in school as well as in the workplace.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial and no non-financial disclosures were reported by the author(s) of this paper.

References

Alper, S., & Raharinirina, S. (2006). Assistive technology for individuals with disabilities: A review and synthesis of the literature. *Journal of Special Education Technology, 21*(2), 47-64. doi: 10.1177/016264340602100204

Anderson-Inman, L., Knox-Quinn, C., & Szymanski, M. (1999). Computer-supported studying: Stories of successful transition to postsecondary education. *Career Development for Exceptional Individuals, 22*, 185-212. doi: 10.1177/088572889902200204

Anttila, H., Samuelsson, K., Salminen, A.-L., & Brandt, Å. (2012). Quality of evidence of assistive technology interventions for people with disability: An overview of systematic reviews. *Technology & Disability, 24*(1), 9-48. doi: 10.3233/TAD-2012-0332

Aud, S., Hussar, W., Kena, G., Bianco, K., Frohlich, L., Kemp, J., … National Center for Education Statistics (ED). (2011). The Condition of Education 2011. NCES 2011-033. *National Center for Education Statistics.* doi: 10.1037/e581062011-001

Behrmann, M. M. (1994). Assistive technology for students with mild disabilities. *Intervention in School & Clinic, 30*, 70-83. doi: 10.1177/105345129403000203

Bouck, E. C. (2016). A national snapshot of assistive technology for students with disabilities. *Journal of Special Education Technology, 31*(1), 4-13. doi:10.1177/0162643416633330

Bouck, E. C., Maeda, Y., & Flanagan, S. M. (2012). Assistive technology and students with high-incidence disabilities: Understanding the relationship through the National Longitudinal Transition Study-2. *Remedial and Special Education, 33*, 298-308. doi:10.1177/0741932511401037

Brackenreed, D. (2008). Assistive technology as an accommodation for a student with mild disabilities: The case of Alex. *Exceptionality Education International, 18*(2), 69-81.

Bryant, D. P., Bryant, B. R., & Raskind, M. H. (1998). Using assistive technology to enhance the skills of students with learning disabilities. *Intervention in School and Clinic, 34*(1), 53-58. doi: 10.1177/105345129803400109

Colker, D. (2002, April 29). Gaining access: Small companies pioneer advances for people with severe disabilities – sometimes by accident. *Journal – Gazette*, 6D. Retrieved from http://prx.library.gatech.edu/login?url=https://search-proquest-com.prx.library.gatech.edu/docview/410997797?accountid=11107

Craddock, G. (2006). The AT continuum in education: Novice to power user. *Disability & Rehabilitation: Assistive Technology, 1*(1/2), 17-27. doi: 10.1080/09638280500167118

Curtis, R. S., Rabren, K., & Reilly, A. (2009). Post-school outcomes of students with disabilities: A quantitative and qualitative analysis. *Journal of Vocational Rehabilitation, 30*(1), 31-48. doi: 10.3233/JVR-2009-0451

Deci, E. L. & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*, 227-268. doi: 10.1207/S15327965PLI1104_01

Edyburn, D. L. (1996). *Assistive technology for students with mild disabilities.* Proceedings of LRP Educational Technology Conference and Expo, San Francisco, CA.

Edyburn, D. L. (2000). Assistive technology and mild disabilities. *Special Education Technology Practice, 8*(4), 18-28.

Edyburn, D. L. (2013). Critical issues in advancing the special education technology evidence base. *Exceptional Children, 80*(1), 7-24. doi: 10.1177/001440291308000107

Elkind, J., Black, M. S., & Murray, C. (1996). Computer-based compensation of adult reading disabilities. *Annals of Dyslexia, 46*, 159-186. doi: 10.1007/BF02648175

Englert, C. S., Manalo, M., & Zhao, Y. (2004). I can do it better on the computer: The effects of technology-enabled scaffolding on young writers' composition. *Journal of Special Education Technology, 19*(1), 5-22. doi: 10.1177/016264340401900101

Fichten, C. S., Asuncion, J., Barile, M., Fossey, M. E., & Robillard, C. (2001). Computer technologies for postsecondary students with disabilities I: Comparison of student and service provider perspectives. *Journal of Postsecondary Education and Disability, 15*(1), 28-58.

Floyd, K. (2012). Postsecondary students with learning disabilities: Can we do more? *Journal of Special Education Apprenticeship, 1*(1), 1-13.

Francis, G., Duke, J., Brigham F., Demetro, K., (2018). Student perceptions of college-readiness, college services and supports, and family involvement in college: An exploratory study. *Journal of Autism* *and Developmental Disorders, 48*, 3573-3585 doi: 10.1007/s10803-018-3622-x

Gamble, M., Dowler, D., & Orslene, L. (2006). Assistive technology: Choosing the right tool for the right job. *Journal of Vocational Rehabilitation, 24*(2), 7380.

Garrison-Wade, D. F. (2012). Listening to their voices: Factors that inhibit or enhance postsecondary outcomes for students with disabilities. *International Journal of Special Education, 27*, 113-125.

Garza, N. (2005). Engagement in postsecondary education, work, or preparation for work. *After high school: A first look at the postschool experiences of youth with disabilities: A Report from the National Longitudinal Transition Study-2 (NLTS2), 1*, 3-1–3-6.

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities, 37*(1), 4-15. doi:10.1177/00222194040370010201

Getzel, E. E., & Thoma, C. A. (2008). Experiences of college students with disabilities and the importance of self-determination in higher education settings. *Career Development for Exceptional Individuals, 31*, 77-84. doi: 10.1177/0885728808317658

Grogan, G. (2015). Supporting students with autism in higher education through teacher education programs. *SRATE Journal, 24*(2), 8-13.

Hansen, K. D., & Dawson, D. L. (2019). “We can do better”: Community college faculty preparedness for teaching students with learning disabilities. *Journal of Diversity in Higher Education. Advance online publication.* doi: 10.1037/dhe0000142

Hasselbring, T. S., & Glaser, C. H. W. (2000). Use of computer technology to help students with special needs. *The Future of Children, 10*, 102-122. doi: 10.2307/1602691

Hall, L. (2016). *A participatory action research study of students with disabilities success at a rural community college: Understanding the heuristics in the black box experience.* Available from ProQuest Dissertation and Theses Global database (UMI No. 10172913).

Hetzroni, O. E., & Shrieber, B. (2004). Word processing as an assistive technology tool for enhancing academic outcomes of students with writing disabilities in the general classroom. *Journal of Learning Disabilities, 37*, 143-154. doi:10.1177/00222194040370020501

Holmes, A., & Silvestri, R. (2012). Assistive technology use by students with LD in postsecondary education: A case of application before investigation? *Canadian Journal of School Psychology, 27*(1), 81-97.

Higgins, E. L., & Raskind, M. H. (2004). Speech recognition-based and automaticity programs to help students with severe reading and spelling problems. *Annals of Dyslexia, 54*, 365-388. doi:10.1007/s11881-004-0017-9

Institute of Education Sciences. (n.d.). National Longitudinal Transition Study 2012. Retrieved from http://ies.ed.gov/ncee/nlts/

Jutai, J., Rigby, P., Ryan, S., & Stickel, S. (2000). Psychosocial impact of electronic aids to daily living. *Assistive Technology, 12*, 123-131. doi:10.1080/10400435.2000.10132018

Kaye, H. S., Yeager, P., & Reed, M. (2008). Disparities in usage of assistive technology among people with disabilities. *Assistive Technology, 20*, 194-203. doi:10.1080/10400435.2008.10131946

LaPlante, M. P., Hendershot, G. E., & Moss, A. J. (1992). Assistive technology devices and home accessibility features: Prevalence, payment, need, and trends. *Advance Data from Vital and Health Statistics*, (217), 1-11. Retrieved from http://www.cdc.gov/nchs/data/ad/ad217.pdf

Lewandowski, L. J., Wood, W., & Miller, L. A. (2016). Technological applications for individuals with learning disabilities and ADHD. In *Computer-Assisted and Web-Based Innovations in Psychology, Special Education, and Health* (pp. 61-93). Elsevier. doi: 10.1016/B978-0-12-802075-3.00003-6

Lindstrom, J. H. (2007). Determining appropriate accommodations for postsecondary students with reading and written expression disorders. *Learning Disabilities Research & Practice*, 22, 229-236. doi: 10.1111/j.1540-5826.2007.00251.x

Lightner, K. L., Vaughan, D. K., Schulte, T., & Trice, A. D. (2012). Reasons university students with a learning disability wait to seek disability services. *Journal of Postsecondary Education and Disability, 25*, 145-159. Retrieved from http://files.eric.ed.gov/fulltext/EJ994283.pdf

Luecking, R. G., & Certo, N. J. (2003). Integrating service systems at the point of transition for youth with significant support needs: A model that works. *American Rehabilitation, 27*(1), 2-9.

MacArthur, C. A. (1999). Overcoming barriers to writing: Computer support for basic writing skills. *Reading and Writing Quarterly, 15*, 169-192. doi: 10.1080/105735699278251

MacArthur, C. A. (2009). Reflections on research on writing and technology for struggling writers. *Learning Disabilities Research & Practice, 24*(2), 93-103. doi:10.1111/j.1540-5826.2009.00283.x

MacArthur, C. A., & Cavalier, A. R. (2004). Dictation and speech recognition technology as test accommodations. *Exceptional Children, 71*, 43-58. doi: 10.1177/001440290407100103

Malcolm, M. P., & Roll, M. C. (2019). Self-reported assistive technology outcomes and personal characteristics in college students with less-apparent disabilities. *Assistive Technology, 31*, 169-179. doi: 10.1080/10400435.2017.1406414

Mavrou, K., Meletiou-Mavrotheris, M., Kärki, A., Sallinen, M., & Hoogerwerf, E. (2017). Opportunities and challenges related to ICT and ICT-AT use by people with disabilities: An explorative study into factors that impact on the digital divide. *Technology & Disability, 29*, 63-75.

Mazzotti, V. L., Test, D. W., Wood, C. L., & Richter, S. (2010). Effects of computer assisted instruction on students' knowledge of postschool options. *Career Development for Exceptional Individuals, 33*(1), 25-40. doi: 10.1177/0885728809338714

McGrath, V. (2009). Reviewing the evidence on how adult students learn: An examination of Knowles' model of andragogy. *Adult Learner: The Irish Journal of Adult and Community Education, 1*, 99-110.

Mechling, L. C. (2007). Assistive technology as a self-management tool for prompting students with intellectual disabilities to initiate and complete daily tasks: A literature review. *Education and Training in Developmental Disabilities, 42*, 252-269.

Mitchem, K., Kight, J., Fitzgerald, G., Koury, K., & Boonseng, T. (2007). Electronic performance support systems: An assistive technology tool for secondary students with mild disabilities. *Journal of Special Education Technology, 22*(2), 1-14. doi: 10.1177/016264340702200201

Mull, C. A., & Sitlington, P. L. (2003). The role of technology in the transition to postsecondary education of students with learning disabilities: A review of the literature. *The Journal of Special Education, 37*(1), 26-32. doi: 10.1177/00224669030370010301

Murray, C. (2002). Supportive teacher-student relationships: Promoting the social and emotional health of early adolescents with high incidence disabilities. *Childhood Education, 78*, 285-290. doi: 10.1080/00094056.2002.10522743

Murray, C., & Pianta, R. C. (2007). The importance of teacher-student relationships for adolescents with high incidence disabilities. *Theory into Practice, 46*, 105-112. doi: 10.1080/00405840701232943

Naik, M., Yorkman, M., & Casserly, M. (2010). Investing wisely and quickly: Use of ARRA funds in America's great city schools [PDF file]. Retrieved from https://www.cgcs.org/cms/lib/DC00001581/Centricity/Domain/293/ARRA%20Report.pdf

Newman, L. A. & Madaus, J. W. (2015). An analysis of factors related to receipt of accommodations and services by postsecondary students with disabilities. *Remedial and Special Education, 36*, 208-

219. doi: 10.1177 /0741932515572912

Ofiesh, N. S., Rice, C. J., Long, E. M., Merchant, D. C., & Gajar, A. H. (2002). Service delivery for postsecondary students with disabilities: A survey of assistive technology use across disabilities. *College Student Journal, 36*, 94-108.

O'Neill, L. N. P., Markward, M. J., & French, J. P. (2012). Predictors of graduation among college students with disabilities. *Journal of Postsecondary Education and Disability, 25*, 21-36. Retrieved from http://files.eric.ed.gov/fulltext/EJ970017.pdf

Parette, P., & Scherer, M. (2004). Assistive technology use and stigma. *Education and Training in Developmental Disabilities, 39*, 217-226.

Perelmutter, B., McGregor, K. K., & Gordon, K. R. (2017). Assistive technology interventions for adolescents and adults with learning disabilities: An evidence-based systematic review and meta-analysis. *Computers & Education, 114*, 139-163. doi: 10.1016/j.compedu.2017.06.005

Phillips, B., & Zhao, H. (1993). Predictors of assistive technology abandonment. *Assistive Technology, 5*, 36-45. doi:10.1080/10400435.1993.10132205

Poudel, B. (2014). Acceptance and use of assistive technology: Perspectives of high school and college students with high incidence disabilities (Doctoral dissertation). Retrieved from http://udspace.udel.edu/bitstream/handle/19716/16818/2014_PoudelBishwa_PhD.pdf

Qualtrics Survey Tool (2019). Georgia Tech Qualtrics Research Suite: https://pwp.gatech.edu/qualtrics/

Rashid, T., & Asghar, H. M. (2016). Technology use, self-directed learning, student engagement and academic performance: Examining the interrelations. *Computers in Human Behavior, 63*, 604-612. doi: 10.1016/j.chb.2016.05.084

Raskind, M. H., & Higgins, E. L. (1995). Effects of speech synthesis on the proofreading efficiency of postsecondary students with learning disabilities. *Learning Disability Quarterly, 18*, 141-158. doi: 10.2307/1511201

Raskind, M. H., & Higgins, E. L. (1998). Assistive technology for postsecondary students with learning disabilities: An overview. *Journal of Learning Disabilities, 31*, 27-40. doi: 10.1177/002221949803100104

Raskind, M. H., & Higgins, E. L. (1999). Speaking to read: The effects of speech recognition technology on the reading and spelling performance of children with learning disabilities. *Annals of Dyslexia, 49(*1), 251-281. doi: 10.1007/s11881-999-0026-9

Raskind, M. H., Higgins, E. L., Slaff, N. B., & Shaw, T. K. (1998). Assistive technology in the homes of children with learning disabilities: An exploratory study. *Learning Disabilities: A Multidisciplinary Journal, 9*(2), 47-56.

Riffel, L. A., Wehmeyer, M. L., Turnbull, A. P., Lattimore, J., Davies, D., Stock, S., & Fisher, S. (2005). Promoting independent performance of transition-related tasks using a palmtop PC-based self-directed visual and auditory prompting system. *Journal of Special Education Technology, 20*(2), 5-14. doi: 10.1177/016264340502000201

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs, 80*(1), 1-28. doi: 10.1037/h0092976

Sennott, S., & Bowker, A. (2009). Autism, AAC, and Proloquo2Go. *Perspectives on Augmentative and Alternative Communication, 18*, 137-145. doi: 10.1044/aac18.4.137

Sharpe, M., Johnson, D., Izzo, M., & Murray, A. (2005). An analysis of instructional accommodations and assistive technologies used by postsecondary graduates with disabilities. *Journal of Vocational Rehabilitation, 22*(1), 3-11.

Stodden, R. A., Conway, M. A., & Chang, K. B. T. (2003). Findings from the study of transition, technology and postsecondary supports for youth with disabilities: Implications for secondary school educators. *Journal of Special Education Technology, 18*(4), 29-44. doi: 10.1177/016264340301800403

Stodden, R. A., & Roberts, K. D. (2005). The use of voice recognition software as a compensatory strategy for postsecondary education students receiving services under the category of learning disabled. *Journal of Vocational Rehabilitation, 22*(1), 49-64.

Wagner, M., Newman, L., Cameto, R., Levine, P., & SRI International, M. P. C. (2005). Changes over time in the early postschool outcomes of youth with disabilities. A report of findings from the National Longitudinal Transition Study (NLTS) and the National Longitudinal Transition Study-2 (NLTS2). Online Submission. Retrieved from https://nlts2.sri.com/reports/2005_06/nlts2_report_2005_06_complete.pdf

Wehmeyer, M. L., Palmer, S. B., Smith, S. J., Parent, W., Davies, D. K., & Stock, S. (2006). Technology use by people with intellectual and developmental disabilities to support employment activities: A single-subject design meta-analysis. *Journal of Vocational Rehabilitation, 24*, 81-86.

Wolfe, G. L., & Lee, C. (2007). Promising practices for providing alternative media to postsecondary students with print disabilities. *Learning Disabilities Research & Practice, 22*, 256-263. doi: 10.1111/j.1540-5826.2007.00254.x.

Wood, S. G., Moxley, J. H., Tighe, E. L., & Wagner, R. K. (2017). Does text-to-speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *Journal of Learning Disabilities, 50*, 1-12.

Woodward, J., & Rieth, H. (1997). A historical review of technology research in special education. *Review of Educational Research, 67*, 503-536. doi:10.2307/1170519

Zabala, J. (1995, March). The SETT framework: Critical areas to consider when making informed assistive technology decisions. Paper presented at the Florida Assistive Technology Impact Conference and Technology and Media Division of Council for Exceptional Children, Orlando, FL.

Appendix

Assistive Technology from High School to College Survey

1. What year did you graduate high school? __________

2. What was your final GPS in high school? __________

3. What is your home/high school zip code? __________

4. How difficult was each of the following for you in high school? Circle one.

Tasks	Easy	Straightforward	I had to work at it	It was hard	It was very hard
Reading	1	2	3	4	5
Writing	1	2	3	4	5
Computation	1	2	3	4	5
Note Taking	1	2	3	4	5
Test Taking	1	2	3	4	5

Subjects	Easy	Straightforward	I had to work at it	It was hard	It was very hard
Language Arts	1	2	3	4	5
Math	1	2	3	4	5
Science	1	2	3	4	5
Social Studies	1	2	3	4	5

5. Did you have a 504 Plan or an IE in high school?
   - ☐ 504
   - ☐ IEP
   - ☐ None of these

6. If so, what was your eligibility?
   - ☐ Attention Deficit/Hyperactivity Disorder
   - ☐ Psychological Disorder
   - ☐ Learning Disability
   - ☐ Systemic Disorder
   - ☐ Mobility Disability
   - ☐ Autism/Asperger's Disorder
   - ☐ Deaf and Hard of Hearing
   - ☐ Vision Impairment
   - ☐ Other

7. What accommodations did you have in high school?
   - ☐ Extra time on assignments and tests
   - ☐ Reader for tests
   - ☐ Notetaker
   - ☐ Quiet room
   - ☐ Take tests over
   - ☐ Electronic text
   - ☐ Other: __________

8. What technology did you use regularly in high school?
   - ☐ PC/Laptop
   - ☐ Tablet (iPad/Android/Surface)
   - ☐ Other: __________

9. How did you feel about using technology (in #8 above) in high school? Circle one.

Very Uncomfortable	Uncomfortable	Neutral	Comfortable	Very Comfortable
1	2	3	4	5

10. Check all of these tools that were available to you in high school.
    - ☐ Screen reader (text-to-speech software)
    - ☐ Speech recognition (speech-to-text software)
    - ☐ Word prediction
    - ☐ Talking word processor
    - ☐ Graphic organizer
    - ☐ Audible textbooks
    - ☐ Spell checker
    - ☐ Electronic dictionary
    - ☐ Audio recorder
    - ☐ Magnification/Enlargement
    - ☐ Other: __________

11. Which of these do you feel you had mastered (very comfortable with) in high school?
    - ☐ Screen reader (text-to-speech software)
    - ☐ Speech recognition (speech-to-text software)
    - ☐ Word prediction
    - ☐ Talking word processor
    - ☐ Graphic organizer
    - ☐ Audible textbooks
    - ☐ Spell checker

- ☐ Electronic dictionary
- ☐ Audio recorder
- ☐ Magnification/Enlargement
- ☐ Other: __________

12. What year did you enter college/tech school? __________

13. What is your college/tech school zip code? __________
14. What was your GPA at the end of the first year in college/tech school? __________
15. How would you describe your first year of college? Circle one.

Very Easy	Easy	Neutral	Difficult	Very Difficult
1	2	3	4	5

16. How difficult was each of the following for you in college/tech school? Circle one for each task/subject.

Tasks	Easy	Straightforward	I had to work at it	It was hard	It was very hard
Reading	1	2	3	4	5
Writing	1	2	3	4	5
Computation	1	2	3	4	5
Note Taking	1	2	3	4	5
Test Taking	1	2	3	4	5

Subjects	Easy	Straightforward	I had to work at it	It was hard	It was very hard
Language Arts	1	2	3	4	5
Math	1	2	3	4	5
Science	1	2	3	4	5
Social Studies	1	2	3	4	5

17. What accommodations did you have in your first year in college/tech school?
    - ☐ Use of a laptop/tablet in class
    - ☐ Extra time on assignments and tests
    - ☐ Reader for tests
    - ☐ Notetaker
    - ☐ Audio recorder
    - ☐ Priority seating
    - ☐ Captioning services
    - ☐ Sign language interpreter
    - ☐ Handouts in advance
    - ☐ Quiet room

- ☐ Take tests over
- ☐ Book in digital (electronic) format
- ☐ Personal attendant (parapro)
- ☐ Other: __________

18. What technology did you use regularly in your first year of college/tech school?
    - ☐ Screen reader (text-to-speech software)
    - ☐ Speech recognition (speech-to-text software)
    - ☐ Word prediction
    - ☐ Talking word processor
    - ☐ Graphic organizer
    - ☐ Audible textbooks
    - ☐ Spell checker
    - ☐ Electronic dictionary
    - ☐ Audio recorder
    - ☐ Calculator
    - ☐ Magnification/Enlargement
    - ☐ Other: __________

19. How did you feel about using these technology tools in college/tech school?

Very Uncomfortable	**Uncomfortable**	**Neutral**	**Comfortable**	**Very Comfortable**
1	2	3	4	5

20. Which of these tools had you mastered/gotten to feel comfortable with by the end of your first year in college/technical school?
    - ☐ Screen reader (text-to-speech software)
    - ☐ Speech recognition (speech-to-text software)
    - ☐ Word prediction
    - ☐ Talking word processor
    - ☐ Graphic organizer
    - ☐ Audible textbooks
    - ☐ Spell checker
    - ☐ Electronic dictionary
    - ☐ Audio recorder
    - ☐ Calculator
    - ☐ Magnification/Enlargement
    - ☐ Other: __________

21. Which tools did you find most valuable or most useful to your academic success?

- ☐ Screen reader (text-to-speech software)
- ☐ Speech recognition (speech-to-text software)
- ☐ Word prediction
- ☐ Talking word processor
- ☐ Graphic organizer
- ☐ Audible textbooks
- ☐ Spell checker
- ☐ Electronic dictionary
- ☐ Audio recorder
- ☐ Magnification/Enlargement
- ☐ Other: __________

22. How did you learn the tool? Select all that apply.
    - ☐ Support from AMAC
    - ☐ Support from Office of Disability Services
    - ☐ Attended training
    - ☐ Self-taught
    - ☐ Viewed tutorials on product website
    - ☐ Friend or peer showed me how to use it
    - ☐ Other: __________

23. Do you think that using AT helped your performance at the post-secondary level?
    - ☐ Yes
    - ☐ No
    - ☐ Unsure

24. Please explain.

25. Gender
    - ☐ Male
    - ☐ Female

26. Race/Ethnicity
    - ☐ Black or African American
    - ☐ Asian or Pacific Islander
    - ☐ Hispanic
    - ☐ Native American
    - ☐ White

27. Age upon enter college: __________

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 77-93
Copyright ATIA 2020 ISSN 1938-7261
Available online: www.atia.org/atob

Driver Training Application for Individuals with Autism

Miriam Monahan, OTD OTR/L CDRS[1], Johnell Brooks, PhD[2], Julia Seeanner, M.S.[2], Casey Jenkins, B.S.[2], Jay Monahan, B.S.[1]

[1]Driver Rehabilitation Institute
Petaluma, CA

[2]Department of Automotive Engineering
Clemson University

Corresponding Author
Miriam Monahan, OTD OTR/L CDRS
Driver Rehabilitation Institute
816 Olive Street
Petaluma, CA 95452
Phone: (802) 233-8724
Email: miriam.monahan@gmail.com

Abstract

Compared to their peers without autism spectrum disorder (ASD), individuals with ASD are more likely to be underemployed and engage in fewer academic and social pursuits. A barrier may be the lack of independence in driving. A usability evaluation of a driver training application, Drive Focus, was conducted. Four rounds of subjects evaluated the application. The rounds alternated between neuro-typical teens and teens or young adults with ASD. There was a decline in the number of comments made within each subject group, suggesting that the iterative process was effective in refining the App. An important component of this work was the utilization of a subject matter expert; in this case, an occupational therapist was part of the usability team.

Keywords: quality improvement, automobile driving, Autism spectrum disorder

Introduction

The transition years into adulthood can be challenging for individuals with autism spectrum disorder (ASD). While most young adults are actively engaged in academic, vocational, and social activities, the majority of individuals with ASD are disconnected. Approximately two-thirds of individuals with ASD in their early 20s are neither employed nor involved in academic pursuits, and one in four are socially isolated (Roux, Shattuck, Rast, Rava, & Anderson, 2015). For young adults with ASD, a barrier to participating in these and other community-based activities may be lack of independence in community mobility, a skill typically achieved in teenage years.

Among all forms of community mobility, Americans are most dependent on the personal automobile (U.S. Department of Transportation, 2015). The ability to drive is a basic skill required to engage in community-based activities, making driving literacy as essential as computer, health, or financial literacy. However, the act of driving is complex, requiring the efficient coordination of sensory, motor, and cognitive skills including executive function skills (Classen, 2010). Individuals with ASD may experience challenges in all of these domains (Classen, Monahan, & Hernandez, 2013). ASD is a common developmental disability affecting one in 59 U.S. children. Of the individuals with ASD nearly half (44%) are classified as having high-functioning ASD and therefore do not have a cognitive disability (Baio et al., 2018). However, individuals with high-functioning ASD may experience difficulty with higher level cognitive skills such as executive function in the areas of divided attention, attention shifting speed, prioritization, inhibition, working memory, and planning (Hill, 2004; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006). Despite these challenges, approximately one in three teens with high-functioning ASD will become licensed drivers, a rate substantially lower than that of their neurotypical peers (83.5%) (Curry, Yerys, Huang, & Metzger, 2017).

Studies suggest that learner and licensed drivers with ASD may make more driving errors than their peers without ASD (Classen et al., 2013; Daly, Nicholls, Patrick, Brinckman, & Schultheis, 2014). Complex driving situations that increase cognitive demands may cause drivers with ASD to have delayed responses to hazards and increased driving errors (Daly et al., 2014; Reimer et al., 2013). The ability of individuals with ASD to recognize and respond to roadway hazards has been the topic of a number of studies. Sheppard, van Loon, Underwood, and Ropar (2016) found that participants with ASD took longer to visually locate a hazard in videos of roadway scenes. Reimer et al. (2013) found that licensed drivers with high-functioning ASD tended to avert their visual gaze away from hazards when driving a simulator. Classen et al. (2013) found that non-drivers with ASD made more adjustment to stimuli errors (not responding to changes in the environment) on a driving simulator compared to their neurotypical peers.

Multiple studies have identified a need for specialized driver training for the ASD population (Almberg, Selander, Falkmer, Ciccarelli, & Flalkmer, 2015; Classen et al., 2013; Cox, Reeve, Cox, & Cox, 2012; Daly et al., 2014; Reimer et al., 2013). Training can require three times as many lessons as novice drivers without ASD (Almberg et al., 2015).

A Certified Driver Rehabilitation Specialist (CDRS) is a professional who provides specialized driver training for individuals with medical conditions. There are approximately 370 CDRSs in North America, the majority of whom are also occupational therapists (OTs) (The Association for Driver Rehabilitation Specialists, n.d.). The inadequate number of professionals to meet the demands suggests a need for intervention tools that do not require the oversight of a CDRS. Unfortunately, there is a lack of evidence-based intervention tools for learner drivers with ASD to use with or without the oversight of a CDRS (Classen & Monahan, 2013).

There is evidence to support the use of technology and particularly video-based technologies to teach individuals with ASD life skills such as self-care, social, and vocational skills (de Bruin, Deppeler, Moore, & Disamond, 2013). When surveyed, 67% of the parents of novice drivers with ASD identified that technology-based programs may be beneficial for teaching their child to drive (Cox et al., 2012). It is thus conceivable that a video-based technology may help individuals with ASD learn driving skills.

Beyond a technology platform, a driver-training tool designed for individuals with ASD should consider instructional methods that support comprehension, a key pillar to literacy. A learner’s comprehension can improve when evidence-based learning preferences are integrated into instructional methods (Schoonover & Press, 2019). For example, integrating visual information (e.g., pictures and videos) is helpful for the ASD population to learn new skills (de Bruin et al., 2013; National Institute for Health and Care Excellence, 2013). Because people with ASD have a tendency to interpret language literally, it is best if language is free of potential ambiguity. People with ASD benefit from routine and structure when participating in activities (National Institute for Health and Care Excellence, 2013). The integration of structure and predictability within a technology may positively influence learning. Lastly, individuals with ASD tend to have more difficulty transitioning skills to new environments. Implementation of strategies that allow individuals with ASD to recognize the similarities between environments helps generalize skills to new environments (National Institute of Mental Health, 2011).

A prototype application for the iPad®, Drive Focus®, was conceptualized by an OT CDRS to address the gap in driving related training tools for individuals with ASD. The specific objective was to design an application to improve visual search skills and hazard recognition. The user learns to identify critical information such as speed limit signs, traffic lights, vehicles, and pedestrians, using a systematic method. The app utilizes an innovative interactive-video technology (not animation) that allows the user to touch on critical information, such as a red traffic light, and receive feedback with simultaneous auditory chimes and visual halos around the object to signify a correct response or an error. The method of training teaches the user to touch on the critical information in order of its priority (e.g., touch the red light before the speed limit sign). If the video is moving too fast for the user, they can slow down the video through the use of three video speed choices and gradually increase the speed of the video as they improve (Drive Focus, 2019). The Drive Focus videos are organized into three levels of complexity where the user navigates through the levels of complexity, increasing in difficulty after attaining a score that unlocks the next level.

To improve the user's experience with products, developers and manufacturers ideally incorporate a usability process at the prototype phase. A usability process may include a heuristic evaluation followed by a usability evaluation (Nielsen, 1993). A heuristic evaluation is conducted by a small number of professionals who typically specialize in human factors and ergonomics (Nielsen, 1993). During a heuristic evaluation the technology prototype is reviewed by the professionals to assess whether it incorporates usability principles. There are five overarching usability principles that a product should incorporate. The product should 1) be easy to learn, 2) be efficient to use once it is learned, 3) be organized logically so that it makes it easy to remember when reengaging with the product, 4) produce minimal user errors, and 5) be pleasing to use (Nielsen, 1993; usability.gov, 2014). Once the heuristic evaluation is completed it may be followed with a usability evaluation.

A usability evaluation further assesses how well the prototype upholds the usability principles when tested with a specific user group or groups (usability.gov, 2014). An iterative testing design is an example of how the prototype may be tested: A group tests the technology prototype, the manufacturer refines the product based on the feedback from the first group, and another group tests the product (Mayhew, 1999). The process should be repeated until the majority of issues are resolved (Mayhew, 1999). A common approach to the iterative design is to observe the user interacting with the prototype while the user "thinks aloud" to verbally state their thoughts and opinions (Nielsen, 1993; usability.gov, 2014). The observations help identify what the user is doing and the think-aloud process helps illuminate why the user is doing what they are doing, and gathers their opinions about the prototype (Nielsen, 1993).

The purpose of the current study was to conduct a usability study on the Drive Focus prototype to ensure the app meets usability guidelines as well as the learning preferences of the ASD population to improve driving literacy.

Target Audience and Relevance

This work is of relevance to both developers of assistive technology products and professionals who work with individuals with ASD. For developers, the work illustrates how the usability process can improve literacy of a subject, in this case driving among the ASD population. The process allowed for refinement of the application to support key elements for achieving literacy: engagement (user satisfaction) and comprehension (ease of learning). In addition to the expertise of a usability team, this work highlights the importance of using a subject matter expert (e.g., OT-CDRS) to integrate instruction methods that support driving and the learning preferences of the ASD population. For professionals working with the ASD population, this work also describes the challenges that individuals with ASD may experience when learning the rules of the road and how technology may help overcome these challenges.

Methods

Prior to initiating this usability evaluation, three rounds of heuristic evaluations took place. These were conducted by a human factors psychologist and two research assistants that are part of the usability team at Clemson University. The Drive Focus team revised the app based on the feedback from the heuristic evaluations before starting the usability evaluation. The Drive Focus team included the OT CDRS, the project manager, app development team, and a graphic designer.

Design

The usability evaluation involved an iterative process of a set of participants testing the Drive Focus application (App), reviewing the results, deciding how to address topics that arose, and refining the App. The entire process was repeated again until four rounds of participants evaluated the App. The first and third rounds of participants were neurotypical teens while the second and fourth rounds were teens and young adults with ASD. This alternating rotation between population groups was used to ensure that the revisions to the App were appropriate for both populations: Changes suggested by one group did not negatively impact the other group.

Participants

The usability team recruited 13 neurotypical teens. Five participated in the first round and eight participated in the third round. The inclusion criteria were 1) age > 14 and < 18 years; 2) any status of driver's license (i.e. no permit, a valid learner's permit, or a driver's license), 3) ability to read and understand English; and 4) an interest in learning how to drive or more about driving. Exclusion criteria were 1) diagnosed with a severe psychiatric condition per parent report; and 2) neurological condition such as ASD per parent report. The participants were compensated for their participation with school service-learning credits.

Participants with ASD were recruited from a pediatrics clinic. Table 1 describes the demographics of both groups.

Table 1: Descriptive Statistics on Demographics of Participants Without ASD and With ASD (N = 24)

Variable	Subjects without ASD (*n* = 13)	Subjects with ASD (*n* = 11)
Gender n (%)		
Female	8 (61.5%)	1 (9%)
Male	5 (38.5%)	10 (91%)
Age in years M (SD)	15.2 (1.2)	16.5 (2.3)
Age range	14-18	13-21
Driving History		
No permit or license n (%)	8 (61.5%)	7 (63%)
Permit drivers n (%)	3 (23.5%)	2 (18.5%)
Licensed drivers n (%)	2 (15%)	2 (18.5%)
Grade M (SD)	9.5 (0.9)	10.1 (2.2)
Use iPad/tablet at home	13 (100%)	7 (63%)

Eleven total participants with ASD enrolled in the study. Six participated in the second round and five in the fourth round. The inclusion criteria were the same as the neurotypical subjects with the changes of 1) ages > 13 and < 21 years; 2) have a physician verified diagnosis of ASD, and 3) be in a regular education setting for at least 75% of the school day. The age for the volunteers with ASD is representative of the age group treated at the clinic that asks about driving. The exclusion criterion was a diagnosis of a severe psychiatric condition per parent report. The subjects were not compensated for their participation.

Setting

The first and third rounds were conducted in an office at the school where the neurotypical teens were recruited. In the second and fourth rounds, the testing was conducted at the university.

Equipment and Materials

An Apple iPad Air® MD 786ll/A, the Drive Focus App, and a notebook containing screenshots of the App were used in all rounds. The Apple iPad was in a case that allowed the subject to lay the iPad flat or stand it at different angles.

Drive Focus application. The Drive Focus App (https://drivefocus.com) is comprised of two main sections: a Training section and a Tour section. The Training section provides instructions on the visual search method, interpreting the scores, and how the App operates. The Tour section contains the Vermont Tour with six interactive videos of drives; two low-, two medium-, and two high-complexity drives. The gradation of the drives is based on the amount of stimuli present.

Drive Focus's Training section. There are six subsections included in the Training section: overview, critical items, priorities, scoring, App controls, and tips.

The *critical items* section instructs the user on the 11 categories of critical items to be aware of as a driver. Critical item categories include stop signs, traffic lights, yield signs, regulatory signs, pedestrians and cyclists, brake lights and turn signals, pavement markings, vehicles entering the driver's path, caution signs, construction signs, and objects in the road. As each critical item is introduced, the instructions explain why that item is critical for the driver to notice, see figure 1.

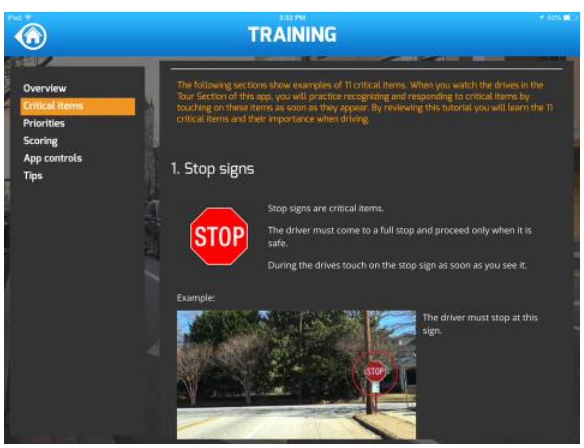


Figure 1: Example of the stop sign in the* critical item *section.

(Drive Focus, 2014)

The *priorities* section instructs the user how to determine what critical items take priority over another.

For example, when approaching an intersection with a green light and the car in front has its brake lights on (both critical items), the brake lights take priority over the green light because the driver may need to slow down or stop. In this case, the user is instructed to touch the brake lights before the green light.

Drive Focus Tour section. The Tour section opens to the Vermont Tour where the user can select a drive (video), see figure 2. The three drives of low complexity are unlocked while the two moderate- and two highest-complexity drives remain locked until an overall score of 500 (50%) or greater is achieved for each respective level. The duration of the drives ranges from three to five minutes.

Figure 2: Image taken from a moderate level drive in the **Vermont Tour.**
(Drive Focus, 2014)

Notebook. Screenshots were taken of each image of the App and compiled into a three-ring notebook in advance of the testing. The notebook was used by the research assistants to write the subjects' participant number, comments, and the researchers' observations next to the related item on the App. After the App was revised between subject rounds, new screenshots were taken and a new notebook was made.

Procedure

All participants and their parents completed a background questionnaire, consent form, and an assent form. The participants were introduced to the study and instructed on the think-aloud process. To ensure that each subject understood the think-aloud process they were given a paragraph to read aloud that had grammatical and wording errors. The participant was asked to identify the errors as they read aloud. The research assistant marked the errors identified to illustrate the role of the researcher.

The participants were asked whether they use an iPad. If a subject did not have experience with an iPad and demonstrated difficulty operating the tablet, the research assistant provided instruction and assistance with functionality of the tablet. Prior to being directed to the Training section of the App, the subjects were given five minutes to explore the App on their own. After the exploration period, the participants were instructed to proceed through the Training sections reading aloud the text while stating their thoughts. After completion of the Training section, the same instructions were given while the participants interacted with the drives in the Tour section. Throughout the Training and Tour sections, the researchers recorded the participants' comments and their observations in the notebook.

Data entry. Participants' demographic information, comments, and observations from the notebook were entered into Excel spreadsheets by a research assistant who did not collect the data. The research assistants that collected the data verified that the comments/observations were entered accurately and coded correctly with regard to 1) the intention (positive, neutral or negative), and 2) one of six general classifications (grammar, formatting, clarification of words, video, images, or other).

After each round of the usability evaluation, the OT-CDRS examined the data and categorized each comment/observation under 1) a construct (user satisfaction or ease of learning) and 2) a benefit for individuals with ASD (beneficial, neutral, or negative). When the OT-CDRS identified problem trends (e.g., several subjects misinterpreted an App function) or overt errors (e.g., punctuation), revisions to the App were recommended. The OT-CDRS documented the decision making process in the spreadsheets: whether the decision to revise the App involved only the OT-CDRS or required a Drive Focus team discussion. The Drive Focus team was consulted when comments or observation had technical and stylistic implications. The Drive Focus team members provided their suggestions as to how to address the problem trend(s) and the OT-CDRS made the final decision. The OT-CDRS also entered into the spreadsheet a rationale to resolve or not resolve the App based on considering the literature.

Data analysis. This descriptive study summarized the participants' comments and researchers' observations for each round of subjects testing the App. The summary included subcategories of comments such as the intention (positive, negative, or neutral), the classification of the comment (grammar, formatting, wording, video, image, or other), the construct (user satisfaction and ease of learning), and justification (benefits to the ASD population). The justifications of the decisions were based on one of four themes from the literature: 1) visual information, 2) concrete language, 3) structure and predictability, and 4) opportunities for generalizing skills can support the learning preferences of individuals with ASD (National Institute for Health and Care Excellence, 2013; National Institute of Mental Health, 2016). The themes were summed to identify the themes the OT-CDRS relied on most when making decisions. Examples of the comments/observations were used to illustrate the influence of the literature on justifying making or not making a change to the App.

The total number of comments/observations that resulted in a change to the App between each round of subjects and in relationship to justification and construct were summarized. In addition, the number of changes made to the App that was decided by the OT-CDRS versus the Drive Focus team was tallied. Lastly, the number of changes made to the App (multiple comments can lead to a single change) was totaled for each round.

Results

Comments and Observations

The participants' comments and researchers' observations were coded by blind research assistants and further categorized by the OT-CDRS after each round of testing; this information is summarized in Table 2. The total number of comments declined between the initial and final session for each of the participant groups (without ASD and with ASD) suggesting that the iterative process of the usability evaluation was helpful in improving the App, using the evidence of the reducing the numbers of items identified.

Table 2: Descriptive Summary of Comments/Observations by Number and Category per Round

Comments/Observations	**Round One** ***n*** **= 5 (Without ASD)**	**Round Two** ***n*** **= 6 (With ASD)**	**Round Three** ***n*** **= 8 (Without ASD)**	**Round Four** ***n*** **= 5 (With ASD)**
Total Number of Comments*	245	125	225	32
Classification of comments/observations*				
Grammar/punctuation/capitalization/ typos	67	23	10	2
Format/bold/color	1	2	3	2
Clarification/word or phrase	104	63	108	14
Video	7	6	35	7
Images	62	12	31	2
Other (can mean multiple categories/general comments)	4	19	38	5
Overall intention of comment/observations				
Positive	41	11	18	1
Negative	32	30	61	13
Neutral	172	85	146	18
Construct				
User Satisfaction	181	91	167	25
Ease of Learning	64	33	58	7
Other	0	2	0	0
Justification				
Beneficial for ASD	16	18	49	6
Neutral for ASD	224	107	151	26
Negative for ASD	5	0	25	0

**Note = coded by research assistant at CU-ICAR versus OT-CDRS*

Each comment/observation was identified by the OT-CDRS as one of three constructs; 1) user satisfaction, 2) ease of learning, and 3) other. The majority of comments/observations were related to user satisfaction and included (a) word changes based on preference versus clarification, (b) the request for less repetition, (c) grammar or punctuation corrections, and (d) general positive comments regarding the experience with the App. Comments/observations related to ease of learning included (a) images did not support the learning, (b) word or phrase were unclear, and (c) positive comments about the information being easy to understand. The "other" category included information that was not representative of the two constructs. Examples of "other" include general comments such as "there are a lot of driving rules".

If a comment/observation justified making a change or not making a change based on the literature related to ASD, it was categorized as beneficial or not beneficial for the ASD population. All other comments that did not have relevance to the ASD literature were considered neutral. The majority of comments/observation in each round were neutral. More importantly, there were more comments/observations that were beneficial to the ASD population compared to negative as seen in Table 2. Such comments helped improve the App for the ASD population.

Literature and Justification

There were four themes in the literature that guided the decisions by the OT-CDRS as to whether the comments/observations suggested a change to the App that would or would not be beneficial for the ASD population. Table 3 summarized the four themes from the literature, the number of times a theme was applied, and examples of comments/observations related to the theme that would either benefit or not benefit the ASD population.

Table 3: Literature that Supported Decisions by OT-CDRS and Frequency of the Application Across All Four Rounds

Themes from the literature	Resources	Beneficial for ASD population example	Total beneficial	Not beneficial for ASD population example	Total not beneficial
Visual information can support learning for individuals with ASD	(de Bruin et al., 2013)	Comment/Observation: Wonders why there is no yellow light picture Problem: The subsection on traffic lights has green light and red light pictures and text. However, there is no picture of yellow light. Decision: Add picture of yellow light and text to explain importance of light.	Total = 21 comments	Comments/Observations: None	Total = 0 comments
Language that is free of potential ambiguity can support learning for individuals with ASD	(National Institute for Health and Care Excellence, 2013)	Comment/Observation: Is there a reason why you changed construction activity to construction site? Problem: Inconsistent wording Decision: Use construction site throughout	Total = 50 comments	Comments/Observation: Replace "items" with "signs" in "Recognizing…" Problem: Subject prefers signs over items, however not all critical items are signs. Decision: No change	Total = 5 comments
For people with ASD their ability to learn new information may be positively influenced with structure and	(National Institute for Health and Care Excellence, 2013; National Institute of Mental Health, 2016)	Comment/Observation: 1) “Doesn't say what to do here” 2) “Add, what you need to do here.” 3) Add "The driver may need to slow down". Problem: Three comments identify that the subsection on vehicles entering the	Total = 11 comments	Comments/Observation: 1) Doesn't think "stop signs are critical items" is needed 2) Doesn't know if it is necessary to repeat "The driver must stop at this sign", because it is already said Problem: Two subjects complained of repetition	Total = 30 comments

Themes from the literature	Resources	Beneficial for ASD population example	Total beneficial	Not beneficial for ASD population example	Total not beneficial
predictability		driver's path was inconsistent with the structure of other sections where the action of the driver is described. Decision: Added "The driver may need to slow down or stop."		Decision: No change because repetition supports predictability	
People with ASD may generalize skills to new environments when they can recognize the similarities between environments.	(National Institute of Mental Health, 2016)	Comment/Observation: 1) Asks about missing pedestrian sign, 2) Asks the question: "Do I have to let people cross the street if there's no sign?" Problem: Two subjects did not understand what action the driver should take when there are pedestrians crossing without a sign. Decision: Provide text to explain that the driver must yield to pedestrians whether there is a sign or not.	Total =7 comments	Comment/Observation: You have already read about red and green lights in the critical items - seems unnecessary at this point. Problem: The subject was complaining about redundancy from Critical item subsection to the Prioritization subsection Decision: No change, the present wording and example supports generalizing information to a new situation.	Total = 1 comments

Changes to the Drive Focus App

Based on the participants' comments and the researchers' observations, 195 changes were made to the App during the usability evaluation and are summarized in Table 4. The total number of comments/observations that resulted in a change across all four rounds was 259. Multiple comments in some cases led to a single change. Some changes were deferred to the next version of the App because of financial constraints that prevented major architectural changes to the App's technology (e.g., adding interactive videos to the Training section).

Table 4: Changes to the Drive Focus App per Category and Round

Changes made by category	Round One *n* = 5 (Without ASD)	Round Two *n* = 6 (With ASD)	Round Three *n* = 8 (Without ASD)	Round Four *n* = 5 (With ASD)
Total number of comments that resulted in a change	132	32	83	12
Change by justification				
Beneficial for ASD	14	16	35	1
Neutral for ASD	118	16	48	10
Negative for ASD	0	0	0	0
Changes by construct				
User satisfaction	92	12	52	9
Ease of learning	40	20	31	2
Other	0	0	0	0

Changes made by category	Round One *n* = 5 (Without ASD)	Round Two *n* = 6 (With ASD)	Round Three *n* = 8 (Without ASD)	Round Four *n* = 5 (With ASD)
Changes by resolution process				
Decisions made by OT-CDRS	111	24	30	1
Decisions made by Drive Focus Team	21	8	53	11
Total number of changes	127	32	28	8
Made in this revision	123	29	21	0
Changes deferred to next version	4	3	7	8

Outcomes and Benefits

Overall there was a decline in the number of changes made after each participant group tested the App. This suggests that the iterative process was effective in refining the App for changes that the OT-CDRS and/or Drive Focus team considered appropriate. The majority of comments/observations in each round were related to *clarification, word choice, or phrase*. The least number of comments were related to *format, bold, or color*. A noteworthy finding was that there was a decline in comments related to *grammar, punctuation, capitalization,* and *typos* between the initial and final session for each of the participant groups (without ASD and with ASD). For the participants with ASD, there was also a decline in comments between the initial and final session for the *clarification/word or phrase.*

In the usability evaluation of Drive Focus, the participants were asked to identify things that were confusing, frustrating, or incorrect. They were not asked to identify positive features about the App. The fact that participants provided positive comments about the Drive Focus App during each round of testing is a favorable indication of user satisfaction.

This experience suggests that involving a subject matter expert with knowledge in ASD and driving in the design and usability testing of Drive Focus helped ensure that the changes to the product were beneficial to the ASD population. Across all four rounds the OT-CDRS identified 89 comments/observations as beneficial changes for the ASD population; 66 (74%) of those resulted in changes. No changes were made to the App that would knowingly be negative to the ASD population according to the literature.

Discussion

The majority of comments/observations (165 out of 259) that resulted in a change were related to user satisfaction. The changes made to the App to improve user satisfaction included correction of *grammar, punctuation, capitalization* and *typos* errors or replacing *words* or *phrases* based on preference. When a single subject identified a grammatical or punctuation error, the error was corrected. In other cases, the OT-CDRS looked for trends in the subjects' comments/observations before making a change to the App. For example, in the Training section there was a picture of a speed bump with a caution sign and the word “hump”. In the text next to the picture, the word “hump” was used to be consistent with the picture. Multiple participants disliked the word “hump” and suggested we use “bump”. The word was changed to “bump” after the first round of subjects. No other comments from later subject rounds requested “hump” to be consistent with the picture.

The entire Drive Focus team was involved when decisions to revise the App could have implications with regards to budget, technical architecture, and the visual experience of the App. For example, multiple participants complained that the images of the score output were too small. The team discussed adding a click and enlarge function, but it proved to be too expensive to change the technology architecture. The final outcome was to replace previous images of the scoring with larger images. This would not make the image full screen (like the click and enlarge), but it made the images larger.

Out of the 195 changes made to the App, 93 were made to improve ease of learning. As in the case of the revisions for user satisfaction, the OT-CDRS typically made decisions without consulting the team when the decision required a word or a phrase change to improve ease of learning. For example, participants identified some sentences as being too long and difficult to understand. The OT-CDRS revised the text with shorter, more concise statements. When writing the text, the OT-CDRS applied the concept of keeping language concrete to support the ASD population's learning preferences (National Institute for Health and Care Excellence, 2013).

Other ease of learning problems identified by the comments/observations required team input. The score output was just such an example. A feature of the score output is a window with a scrollbar that allows the user to view each critical item that appeared in the video scenario and score details related to 1) identification, 2) the selection of priority, and 3) the response time for each critical item. The research assistants observed that a number of participants did not recognize the window as having scrolling functionality. The scrollbar used adhered to Apple specifications (small and slender). Since enlarging the scrollbar or changing the color of the scrollbar was not permitted by Apple, the team explored other options. After searching for similar windows in other apps and creating multiple conceptual diagrams, the team decided to fade the last item of the scroll window, to illustrate that there was more information below. The fading of the last item in the window is used in other products with scroll windows, and therefore makes it more recognizable to the user that it is a window with scrolling functionality.

Subject Matter Expert Collaboration in the Usability Evaluation

The collaboration with the OT-CDRS as the subject matter expert in the usability evaluation was critical for its success. The usability team provided the expertise in planning, recruiting, and implementing the iterative study design as well as the skills for collecting data, while the OT-CDRS provided knowledge on how individuals with ASD perceive and process information. This knowledge was applied when making decisions on whether and how to revise the App. The OT-CDRS routinely considered four themes from the literature when making decisions. The themes identified that the ASD population's learning preferences typically benefit from visual information, concrete language, predictability and structure, and opportunities to generalize new information.

There was one circumstance where the OT-CDRS needed to consult the literature beyond these four themes before making a revision. Initially, the App was designed with two auditory tones, a chime to indicate the user correctly touched a critical item and a “bonk” sound when the user touched a non-critical item. A few participants commented that a third sound was needed to indicate that the item had already been touched. The Drive Focus team thought that suggestion was a good idea. However, the OT-CDRS was concerned about introducing another sound. The OT-CDRS knew from clinical experience that auditory processing could be a challenge for the ASD population but was uncertain whether this difficulty was associated with discrimination of tones. The literature suggested that individuals with ASD have either typical or enhanced auditory discrimination of tones compared to their peers without ASD (Bonnel et al., 2010; Jones et al., 2009; O'Connor, 2012). However, individuals with ASD can experience hypersensitivity to sounds that are typically loud, sudden, or high-pitched (O'Connor, 2012). Based on the literature, the OT-CDRS decided it would be appropriate to add a third tone, but the tone should be consistent with the volume of the other two tones while being readily distinguishable. The third tone selected was a two-note electronic, low-pitched sound.

Out of the four themes that guided the OT-CDRS’s decisions to revise or not revise the App, the majority (50) were based on the theme that language that is concrete can support the ASD population’s learning preferences (National Institute for Health and Care Excellence, 2013). Given that the Training section has mostly text compared to images or videos, it was not surprising that this theme was used the most. The majority of comments/observations that suggested a change that could be potentially negative for the ASD population’s learning preferences were complaints about the repetition of the instructions to “touch on the specific critical item” whenever they saw it in the Tour videos. The OT-CDRS rejected these suggestions for concern that the ASD population would benefit from the repetition (Foster & Cox, 2013; National Institute for Health and Care Excellence, 2013; National Institute of Mental Health, 2011). There were 30 comments in total that requested less repetition in the Training section; of those, 24 came from the group without ASD and six came from the group with ASD. Thus, the participants without ASD found the repetition less necessary compared to the group with ASD. The OT-CDRS’s decision not to reduce the repetition was to maintain the App in accordance to the ASD population’s learning preferences.

The usability evaluation of Drive Focus was essential for improving comprehension and ultimately literacy of the instructional material. In the case of the Drive Focus App, information from the literature and clinical expertise guided the decisions to revise the App to improve the comprehension and user engagement. However, the participants provided valuable insights that resulted in 195 revisions to the App. The number of revisions underscores the benefits of a usability evaluation even when the developer has strong knowledge of the targeted population.

Limitations and Future Research

Limitations of this usability evaluation includes the lack of detailed demographic information about the ASD participants, such as reading level, and whether medications were prescribed and taken for attention during the session. Future research should be a study to determine how much the Drive Focus App helps individuals with ASD develop visual search skills for driving. It was a pleasant surprise to hear many participants, both neurotypical and ASD, comment, “I did not know that.” It will be helpful to know how much Drive Focus training is needed to have a significant change for the ASD population. For example, does it take two or ten hours before a measurable change occurs. It will also be useful to replicate this usability study for other samples ranging from stroke patients to drivers from different countries who need to gain experience prior to getting behind the wheel of a vehicle.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author(s) of this paper.

Acknowledgements

The authors would like to thank Christ Church Episcopal School in Greenville, SC, for their generous support in hosting the researchers for several months during data collection and in encouraging their students to take part in our research. Thanks to Drs. Julie Kellett, Carrie Buchanan, and Desmond Kelly from the Department of Pediatrics at the Children's Hospital of the Prisma Health–Upstate for their valuable advice and assistance. Doctoral advisor, Kate Barret, OTD, OTR/L and Doctoral Committee Members: Kathleen Matuska PhD, OTR/L, Elizabeth Perra, OTD, OTR/L, Karen Sames OTD, MBA, OTR/L, FAOTA, and Erica Sterns PhD, OTR/L, FAOTA for their guidance through the project. Finally, the authors would like to thank Diann Tinsley for her administrative support.

References

Almberg, M., Selander, H., Falkmer, M. Vaz, S., Ciccarelli, M., & Flalkmer, T. (2015). Experiences of facilitators or barriers in driving education from learner and novice drivers with ADHD or ASD and their driving instructors. *Developmental* Neurorehabilitation, *20*(2), 59-67. doi:10.3109/17518423.2015.1058299

Baio, J., Wiggins, L., Christensen, D. L., Maenner, M. J., Daniels, J., Warren, Z., …Dowling, N. F. (2018). Prevalence of autism spectrum disorder among children aged 8 years– autism and developmental disabilities monitoring network, 11 sites, United States, 2014. *Morbidity and Mortality Weekly Report, 67*(SS-6), 1-23. doi: http://dx.doi.org/10.15585/mmwr.ss6706a1External

Bonnel, A., McAdams, S., Smith, B., Berthiaume, C., Bertone, A., Ciocca, V., …Mottron, L. (2010). Enhanced pure-tone pitch discrimination among persons with autism but not Asperger syndrome. *Neuropsychologia, 48*, 2465-2475. doi:10.1016/j.neuropsychologia.2010.04.020

Classen, S. (2010). From the desk of the editor: Special issue on older driver safety and mobility. *American Journal of Occupational Therapy, 64*, 211-214. doi:10.5014

Classen, S., & Monahan, M. (2013). Evidence based review on interventions and determinants of driving performance in teens with attention deficit hyperactivity disorder or autism spectrum disorder. *Traffic Injury Prevention, 14*, 188-193. doi:10.1080/15389588.2012.700747

Classen, S., Monahan, M., & Hernandez, S. (2013). Indicators of simulated driving skills in adolescents with autism spectrum disorder. *The Open Journal of Occupational Therapy, 1*(4). Retrieved from http://scholarworks.wmich.edu/ojot/vol1/iss4/2/

Cox, N. B., Reeve, R. E., Cox, S. M., & Cox, D. J. (2012). Brief report: Driving and young adults with ASD: Parent's experiences. *Journal of Autism and Developmental Disorders, 42*, 2257-2262. doi:10.1007/s10803-012-1470-7

Curry, A. E., Yerys, B. E., Huang, P., & Metzger, K. B. (2017). Longitudinal study of driver licensing rates among adolescents and young adults with autism spectrum disorder. *Autism*, 1-10. doi:10.1177/1362361317699586

Daly, B. P., Nicholls, E. G., Patrick, K. E., Brinckman, D. D., & Schultheis, M. T. (2014). Driving behaviors in adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44*, 3119-3128. doi:10.1007/s10803-014-2166-y

de Bruin, C. L., Deppeler, J. M., Moore, D. W., & Disamond, N. T. (2013). Public school–based interventions for adolescents and young adults with an autism spectrum disorder: A meta-analysis. *Review of Educational Research, 83*(4), 521-550.

Drive Focus. (2019). Let's get ready to drive. Retrieved from https://drivefocus.com/

Foster, L., & Cox, J. (2013). Best practices in supporting students with autism. In G. Frolek Clark & B. Chandler (Eds.), *Best practices for occupational therapy in schools* (pp. 273-284). Bethesda, MD: AOTA Press.

Hill, E. L. (2004). Evaluating the theory of executive dysfunction in autism. *Developmental Review, 24*, 189-233.

Jones, C. R. G., Happé, F., Baird, G., Simonoff, E., Marsden, A. J. S., Tregay, J., …Charman, T. (2009). Auditory discrimination and auditory sensory behaviours in autism spectrum disorders. *Neuropsychologia, 47*, 2850-2858. doi:10.1016/j.neuropsychologia.2009.06.015

Mayhew, D. J. (1999). *The usability engineering lifecycle: A practitioner's handbook for user interface design.* San Francisco, CA: Morgan Kaufmann Publishers, Inc.

National Institute for Health and Care Excellence. (2013). The management and support of children and young people on the autism spectrum. *NICE Clinical Guidelines.* Retrieved from guidance.nice.org.uk/cg170

National Institute of Mental Health. (2011). A parent’s guide to autism spectrum disorder. Retrieved from http://www.nimh.nih.gov/health/publications/a-parents-guide-to-autism-spectrum-disorder/index.shtml

National Institute of Mental Health. (2016). Autism Spectrum Disorders. Retrieved from https://www.nimh.nih.gov/health/topics/autism-spectrum-disorders-asd/index.shtml

Nielsen, J. (1993). *Usability engineering.* Cambridge, MA: AP Professionals.

O'Connor, K. (2012). Auditory processing in autism spectrum disorder: A review. *Neuroscience and Biobehavioral Reviews, 36*, 836-854. doi:10.1016/j.neubiorev.2011.11.008

Reimer, B., Fried, R., Mehler, B., Joshi, G., Bolfek, A., Godfrey, K. M., …Biederman, J. (2013). Brief report: Examining driving behavior in young adults with high functioning autism spectrum disorders: A pilot study using a driving simulation paradigm. *Journal of Autism and Developmental Disorders, 43*, 2211-2217. doi:10.1007/s10803-013-1764-4

Roux, A. M., Shattuck, P. T., Rast, J. E., Rava, J. A., & Anderson, K. A. (2015). *National autism indicators report: Transition into young adulthood.* Philadelphia, PA: Life Course Outcomes Research Program, A.J. Drexel Autism Institute, Drexel University.

Schoonover, J., & Press, M. (2019). Best practices in the use of assistive technology to enhance participation. In G. F. Ckark, J. E. Rioux, & B. E. Chandler (Eds.), *Best practices for occupational therapy in schools* (2nd ed., pp. 169-176). Bethesda, MD: American Occupational Therapy Association, Inc.

Sheppard, E., van Loon, E., Underwood, G., & Ropar, D. (2016). Attentional diferences in a driving hazard perception task in adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 47*, 405-414. doi:10.1007/s10803-016-2965-4

The Association for Driver Rehabilitation Specialists. (n.d.). CDRS vs DRS. Retrieved from https://www.aded.net/page/230

U.S. Department of Transportation. (2015). Beyond traffic: US DOT's 30 year framework for the future. Retrieved from https://www.transportation.gov/BeyondTraffic

usability.gov. (2014). Usability evaluation basics. Retrieved from http://www.usability.gov/what-and-why/usability-evaluation.html

Verté, S., Geurts, H. M., Roeyers, H., Oosterlaan, J., & Sergeant, J. A. (2006). Executive functioning in children with an autism spectrum disorder: Can we differentiate within the spectrum? *Journal of Autism and Developmental Disorders, 36*, 351-372. doi:10.1007/s10803-006-0074-5

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 94-110
Copyright ATIA 2020 ISSN 1938-7261
Available online: www.atia.org/atob

The Evolving Landscape of Assistive Technology in K-12 Settings

Denise C. DeCoste[1] and M. Gayl Bowser[2]

[1]Falmouth, MA

[2]Camas Valley, OR

Corresponding Author
Gayl Bowser
6713 Upper Camas Road
Camas Valley, OR 97416
Phone: (541) 445-3047
Email: gaylbowser@gmail.com

Abstract

This paper focuses on the evolving landscape of assistive technology (AT) in school-based settings. It explores the change forces affecting AT, for sole providers of AT services and for AT teams. After 30 years of assistive technology service delivery, it is time for AT providers to re-examine whom we serve and how we serve, now and in the future.

Keywords: assistive technology services, building capacity, change forces, AT teams, AT leaders, AT service provider, K-12 education, professional learning, documentation and accountability, outreach.

Introduction

For the past 30 years, federal laws such as the 1988 Tech Act and the Individuals with Disabilities Education Act (1990) have guided us in the delivery of Assistive Technology (AT) devices and services. AT was first addressed by Congress in the 1998 Assistive Technology Act. The act did not specifically address AT in education, but was intended to apply to persons of all ages in the general population who have disabilities. AT became more specifically incorporated in law as part of special education IDEA amendments that linked it to AT consideration within the IEP process.

Each of these laws has implications for the activities of AT Teams. For the purposes of this paper, the terms "AT specialist" and "AT service provider" are used interchangeably and refer to those individuals who have a leadership role in designing services that support the use of AT in classrooms. As identified in this article, "AT teams" may be a loosely formed group of AT specialists or a formal multidisciplinary team assigned to manage a range of AT services. The term "school teams" refers to staff interacting with students throughout the school day.

A variety of professional development organizations and individual AT specialists have influenced the field of AT as it developed and matured. The Education Tech Points framework (Bowser & Reed, 2012) was first published in 1995 and provided a structure for AT services in educational settings. The SETT (Student-Environment-Tasks-Tools) framework for addressing AT concerns was presented at the Closing the Gap (CTG) conference in 1995 (Zabala, 1995). The Wisconsin Assistive Technology Initiative (Reed, 1994) defined essential elements of a comprehensive AT assessment in a way that was accessible to school providers and educational teams. CTG and other major professional development organizations, such as the Assistive Technology Industry Association (ATIA), the California State University, Northridge (CSUN) Assistive Technology Conference, and the Innovations in Special Education Technology (ISET) division of the Council for Exceptional Children, have, for many decades, sponsored professional development opportunities on a wide variety of AT topics. State-sponsored AT projects in many states provide technical assistance, professional development, referral information and resources to local and regional AT providers in education settings. The Quality Indicators of Assistive Technology (QIAT) consortium has published eight sets of "quality indicators" to guide excellence in AT service delivery (The QIAT Leadership Team, 2015). These and many others have served to guide the development and provision of AT services to date.

Over the past three decades, a variety of shifts have occurred in education, affecting the provision of AT services. Notable among these shifts are a trend toward the education of students with disabilities in inclusive settings; the enhancement of educational technology by the addition of accessibility features in most technology platforms; and a move to more individualized student instruction and support. Michels (2017) identified three specific educational initiatives that are having a significant effect on AT services: 1) Differentiated Instruction (DI)/Personalized Learning, 2) Response to Intervention (RtI)/Multi-Tiered Systems of Support (MTSS), and 3) Universal Design for Learning (UDL). While each of these frameworks has its own descriptive language, the focus on learner variability and multiple means of instruction tied to student needs is a common denominator. The role of general and special educators is being redefined within these initiatives, and so, too, is the relationship with AT providers. Special education is less often provided in a self-contained classroom as services are increasingly delivered in inclusive settings. Moreover, the focus within education is moving away from any notion of the average learner and toward personalizing instruction for a wide range of learners.

Research that sheds light on achievement and engagement gaps provides the impetus behind some of these educational initiatives. This includes research analyzing the effects of poverty on learning (American Psychological Association, 2018; American Psychological Association, Presidential Task Force on Educational Disparities, 2012; Kena et al., 2015), evaluation of the stagnant achievement gap for students with English as a second language (Musu-Gillette et al., 2016; US DOE, Office of English Language Acquisition, January 2016), and research on the gradual decline of student engagement during the middle and high school years (Calderon & Yu, June 1, 2017). In light of this research and the shift to focusing on individualizing instruction for all learners, the question arises: Who are AT providers serving and who should have primary responsibility for AT support in K-12 education?

Change Forces Impacting AT Services

Michels's (2017) research also describes three current change forces impacting the ways that AT services are provided. They include changes in the student population, the ubiquitous and more universal nature of educational technology, and the blurring of the lines between AT and instructional technology (IT). Quinn et al. (2009) demonstrated that AT services were disproportionally provided to low-incidence populations. Conversations with more than 600 AT providers as part of a course on the changing role of AT teams suggests that, ten years later, this is still typical. A survey of over 500 alumni of *the Changing Roles of AT Teams* courses (DeCoste & Bowser, 2019) also indicates that district AT providers rarely consider equity of AT services across disability, racial, and socioeconomic status. If equity is defined as dealing fairly and equally for all concerned, then it is important for districts to ensure that access to AT is delivered proportionally to students with low- and high-incidence disabilities. Bouck (2016) offers a secondary analysis of the National Longitudinal Transition Study-2 focused on understanding issues of AT for secondary (i.e., high school) students with disabilities. Her analysis suggests low rates of AT access and/or use in general for secondary students with disabilities, but higher rates of AT for secondary students with more low-incidence disabilities than students with more high-incidence disabilities. An equally important question is whether AT services are proportional across racial and socioeconomic lines, or if, instead, the referral process results in more and better services for children with strong teacher and parent advocates.

The second change force impacting AT services is the evolution of AT devices themselves. Many features (e.g., magnification, text-to speech, word prediction, speech-to-text) required by learners with disabilities are currently already embedded in software included on commonly available laptops and portable tablets. Such options built into mainstream devices make assistive technology more available to a wider range of students and teachers while they also decrease the stigma attached to specialized, stand-alone AT devices and accessibility features.

Michels's (2017) third factor, the more universal nature of educational technology, blurs the lines between AT and IT. For example, the UDL framework uses proactive instructional design and is a logical first step for incorporating technology into classroom instruction. From the outset, instruction is designed to offer multiple means of engagement, choices on how information is presented, and multiple ways for learners to represent what they know. Educators work with students to guide their choices to meet individual needs. Because of the flexibility they offer, instructional technology and assistive technology are an integral part of the UDL framework for all learners. MTSS, RTI, and Differentiated Instruction (DI) guide the decisions that teachers use in the selection of learning opportunities once student needs are identified. UDL, MTSS, RTI, and DI all seek to personalize learning for students needing additional supports. The tools that are selected (e.g., screen enlargement, text-to-speech, speech-to-text, word prediction) are often readily available, and may not be considered AT tools. Classroom teachers who are providing digital instruction, particularly those implementing UDL and those in one-to-one device classrooms, may find it hard to understand the distinction when accessibility tools are used by choice by a wide range of learners, yet must be documented as AT for specific learners with disabilities.

The educational initiatives and the change forces described above create a need to examine the way we deliver AT services. The current population of students who can benefit from AT is often too large for AT teams to address in the typical one-student-at-a-time manner. Expert models of service delivery are often unsustainable (Reed, 2004; Edyburn, 2000). The focus on personalizing instruction for all learners and the availability of more universal technology that benefits students in the margins due to lack of engagement or to learning issues mean there is a broader audience of students and teachers to serve. AT teams need to adapt to this evolving educational landscape, or risk being overwhelmed by individual demands for service.

Michels (2017) studied AT teams that are part of educational cooperatives. She hypothesized that AT teams are in a state of change and that simple adaptation of traditional designs of AT services may be insufficient. Those teams unable to evolve run the risk of dissolution. Wright (2000) examined the role of Educational Service Agencies (ESAs) and found that that ESAs that survived had evolved from serving students with disabilities in isolated settings to serving students with disabilities in inclusive settings, and then to serving all students. Agencies that use per-student or fee-for-service funding models have generally had to redesign their models as their costs have been too high for districts to justify using contracted services.

In the beginning, the expert model of AT service delivery was considered the optimal model for AT services. It is based on the assumption that agencies will have sufficient AT resources and providers to offer equitable services across all types of disabilities. In the absence of sufficient resources, a typical recourse for AT teams is to limit AT services to the learners most impacted by disabilities, typically students with complicated, low-incidence disabilities. Another recourse is for AT services to default to "concierge" type services. However, such services respond only to individual referrals in ways that do not ensure equity and are not in keeping with current educational paradigms to provide support to a broad range of students who can benefit from AT. It is our contention that AT service design models must move beyond the one-size-fits-all model of service delivery, where the process (e.g., referral, formal or informal assessment, trial period, implementation plan, evaluation of effectiveness) is the same for all students regardless of the learning environment and the technology knowledge base of school teams. It is our view that it is essential for AT providers to build the capacity of school teams to conduct appropriate AT assessments and help their students utilize tools while still having access to the AT supports, guidance, coaching, and mentoring that are needed to support the broadest range of educators and learners.

Outcomes and Benefits

In a brief written by the Center to Improve Project Performance (CIPP) operated by Westat for the U.S. Department of Education, Office of Special Education Programs (OSEP), capacity building is defined as follows:

> *"Capacity building is an intervention that strengthens an organization's ability to fulfill its mission by promoting sound management, strong governance, and persistent rededication to achieving results." (Lammert et al., 2015, p.1)*

Building AT capacity in K-12 settings is needed to fulfill the mission of districts to support all students in becoming life-long learners. In order to build the capacity to provide AT, AT teams and the agencies they serve must share a vision of the outcomes of AT use. A sample school district vision for AT services provided to one student at a time might look like this: *Students with disabilities use the AT devices and services they need and show increased benefit from FAPE because of AT.* Unfortunately, the experience of a wide variety of AT teams is that such a vision is not sustainable within the context of sound management and governance. An alternative vision of AT capacity building employs a UDL approach with an emphasis on equity, management, governance, and rededication to achieving results that is focused on the actions of teachers: *"As teachers organize their curriculum and instruction to support diverse groups of students, individualized technology accommodations are embedded and delivered in the context in which students work together."* (Woodward & Cuban, 2000, p.3)

In this paper, *building AT capacity* refers to this more sustainable way to deliver AT services: meeting the needs of a changing population of students at a time when we have the ability to personalize instruction for a wide range of learners using more readily accessible technology. It refers to building administrative support for developing new ways of delivering and documenting AT. And it refers to multiple ways of providing professional development, building on-demand resources, and reaching out to other stakeholders within the educational organization. Capacity building requires AT providers and classroom educators to let go of a hierarchical approach to AT service delivery and find new ways to build shared ownership of AT. A capacity building vision expects that teachers will increasingly develop knowledge and independence in providing instruction that includes AT used by their students who need it.

Agency leaders play an essential role in the promotion, sound management, and governance of AT teams and AT service providers who are designated to support the needs of struggling students in general education classrooms. Administrators have a responsibility to ensure suitable resources and an appropriate knowledge base for all AT providers. They also ensure a smooth transition and the maintenance of AT expertise when personnel shifts occur. Overall, AT providers and supervisors must be dedicated to the importance of AT and share a vision for its role in educational programs. Leadership's role in agency self-assessment can ensure that there is also a common vision for capacity building.

Bowser and Reed (2018) discuss essential aspects of AT leadership, all of which must be addressed if AT supports are to be useful and readily available. School administrators are the leaders of the vision for the programs they serve, whether it is a specific program, a building, or an entire agency. In addition to their overall leadership responsibilities, school administrators engage in three types of activities. They: (a) manage the programs for which they have responsibility; (b) supervise the staff employed in these programs; and (c) lead program development and improvement efforts. Providing effective AT services requires a school administrator to address assistive technology from each of these administrative perspectives. As managers, school administrators sign purchase orders for new equipment and ensure consistent and equitable services. As supervisors, school administrators ensure that the agency has qualified staff members who are knowledgeable about AT and the technology needs of students with disabilities. As leaders in program development, school administrators include AT in long-term planning efforts. A move to a differentiated and capacity building approach to AT services requires understanding and collaboration on the part of school administrators and other AT leaders.

A capacity-building approach does not negate the importance or need for AT experts. Classroom teachers often have access to AT tools and accessibility features but know little about them. Some also have students whose need for AT goes beyond what is universally available. While school teams will likely be able to assess common reading and writing issues, they are unlikely to have the skill set to analyze less frequently seen AT needs such as physical access to technology, Braille, or augmentative communication. AT service design should not be an either/or choice between one-student-at-a-time and capacity building. AT teams need to find ways to differentiate services that they provide as experts and consultants, but also work to collaborate and coach school teams to build independence in educators within the school environment. The most important element for AT teams is to have a clearly defined mission that matches the identified needs of students and staff within the educational organization. Knowing who is served within the district and analyzing the degree to which equitable services are provided across the organization are critical to re-envisioning strategies for the delivery of AT.

Expectations for AT Teams

AT tools are no longer the sole domain of AT experts, as there is broad-based exposure to AT features, like word prediction on mobile phones, and everyday speech recognition built into productivity software and operating systems. Many accessibility (AT) features are now incorporated into mainstream technology. There are solutions such as Google Speak and text-to-speech features in online curricula. There are many free apps to check grammar and take notes. There is less novelty around AT since accessibility features are incorporated into everyday devices. There are video tutorials on vendor websites and YouTube to learn how to use these everyday tools. Given that so much information is readily available, what should be the expectations for today's AT teams? Michels (2017) conducted survey research to determine current perceptions. She found that educators expect the following from AT providers:

1. A broad technology expertise across AT and IT.
2. A broad role in ongoing support (e.g., coaching, job-embedded training, capacity building, curriculum support).
3. AT providers as technology thought leaders.

Broader Technology Expertise Across AT and IT

While it is critical for AT providers to maintain their knowledge base in assistive technology, educators also expect them to have breadth and depth of instructional technology knowledge. The majority of struggling learners are in general education classrooms where instructional technology is used routinely. According to the National Educational Statistic Center (2017), 63% of students with disabilities are educated in general education classrooms more than 80% of the day. Another 18% are in general education classrooms more than 40% of the day.

Given the rate of inclusion in general education classrooms, teachers expect that AT providers will understand how AT and IT intersect. Teachers need AT providers to be able to address questions such as: How can students with disabilities use online multimedia posters that combine images, graphics, audio, video, and text to convey what they know? How would augmented reality tools support students with moderate to severe disabilities? What supplementary tools are needed for students with disabilities to research topics and write informational text? How do text-to-speech tools and note-taking tools enhance close reading? A broader and deeper knowledge of instructional technology is as important as knowledge of AT for students with disabilities in general education classrooms.

Broader Roles for Providing On-going Support

Just as they are needed for students, multiple tiers of support are needed to transfer skill sets to classroom staff. For example, if a school team that requests AT support for a student is unfamiliar with the SETT framework, the AT service provider may want to model the agency's SETT process with the team and family. When a new student is referred from the same school team, the AT provider could encourage a staff person to facilitate the meeting, in collaboration with the AT service provider. Subsequently, the AT service provider would coach the school team, reassuring team members that they can conduct the SETT meeting on their own and then confer afterwards. This process of building capacity for AT consideration should be flexible, offering ongoing support as needed, but can send a clear message that the role of the AT service provider is to help the school team develop knowledge and confidence. If the AT consideration process always points back to an AT provider as the starting point, it establishes a practice barrier to building capacity. Capacity building is not accomplished overnight or merely by changing the rules. It is a gradual process of scaffolding information and coaching school teams.

Assessment can also be a collaborative process. Classroom staff are most familiar with student abilities and should share in the assessment process. For example, the DeCoste Writing Protocol (DeCoste, 2014) uses a 4-part process to identify writing deficits. The school occupational therapist and teacher can collaborate with the AT service provider to administer portions of the protocol. UPAR (DeCoste & Wilson, 2012) is an online tool from Don Johnston, Inc. that compares reading comprehension using text-to-speech and pre-recorded audio recordings against an independent reading baseline. It was designed to be easily administered by school staff to a group of students identified as having reading delays. Another example of how collaboration can take place is in the administration of the Communication Matrix Assessment (Rowland & Fried-Oken, 2010) or the collection of data on core vocabulary for Augmentative and Alternative Communication (AAC) users. Coaching school level teams to take on more of the assessment builds ownership at the local level for target students and for others served by the school team.

AT support does not have to be a one-size-fits-all, linear process. Experienced school teams may conduct the SETT process on their own, but confer with AT specialists to discuss appropriate tools. AT service providers can use video conferencing, send links to resources via email, or direct school staff to resources on the AT website. They can also help school teams set up trial periods or develop implementation plans documenting effective tools and strategies. AT team support should be flexible and offer multiple means of support, both direct and indirect. Differentiated AT support is an essential component when building capacity within an agency. AT service providers have a responsibility to examine each request for support with an eye to helping build the skills of classroom staff. More students benefit when this occurs.

Table 1: Elements of Differentiated AT Support to Build Capacity

	Consultation	**Collaboration**	**Coaching**
Goal	To inform	To work together	To transform
Focus	On AT content	On AT partnership	On transfer of AT skill sets
Style	Telling	Discussing	Inquiry
Accountability	AT specialist	Designated school staff	Classroom team
Support Role	Expert	Colleague	Mediator or mentor

(adapted from Bowser and Reed (2012))

Professional development should also be viewed as a range of support options. Table 1 illustrates the ways that differentiated strategies for support can be used to enhance the independence of educators' use of AT in the classroom. Face-to-face (f2f), one-on-one support to teachers should be used appropriately, but sparingly. Whenever possible, direct consultation should be provided to multiple school staff. Agency capacity is built by encouraging independence among classroom educators who can then apply their AT skills to student needs without direct assistance from AT team members. AT services can also be delivered through video conferencing. It is an effective, time-efficient way to provide support on specific AT topics. Workshops on targeted topics can be f2f or presented via a live webinar. Webinars can be recorded and posted on the AT team's website as a way to build on-demand resources, along with links to resources on AT topics. Screen capture software can be used to create short videos on frequently requested topics. Professional learning communities can use synchronous and asynchronous webinars to dive deeper into complex topics (e.g., AAC, visual impairment, behavioral supports). Because release time, funding, traffic, and after-school activities often prevent staff from attending face-to-face workshops, asynchronous resources are critical.

Not only should professional development topics be available in multiple formats to ensure just-in-time support, but they should be differentiated to ensure that the format and content of professional learning opportunities are appropriate for the various audiences they are designed to reach. For any comprehensive professional development effort, there are three primary audience groups: classroom educators who serve students on a daily basis, program level staff who provide consultation, collaboration, and coaching to classroom staff, and administrators at the district level who will supervise and assess the effectiveness of the program. When AT service providers develop professional learning opportunities that can meet the needs of each of these groups, true agency-wide capacity building is more likely to occur.

AT Service Providers as Technology Thought Leaders

Some individuals are leaders because of the assigned administrative position that they fill (e.g., school principal, special education director). Other individuals may become leaders in changing AT services because of their knowledge of AT devices and services or the way others in a group respond to them. Northouse (2016) labels these two types of leaders as "assigned leaders" and "emergent leaders." In their survey of established AT teams, DeCoste, Reed, and Kaplan (2005) found that only 20% of the teams surveyed stated that assigned leaders (i.e., administrators) initiated their AT team development. More commonly, AT team activities were developed as enthusiastic direct service providers saw a need for AT coordination. These individuals and the vision they bring are “thought leaders.”

Despite the enthusiastic efforts of thought leaders, without direct administrative support, AT improvement efforts are likely to be less effective and more difficult to sustain. In an international synthesis of research about successful school leadership, Leithwood, Harris, & Hopkins (2008) noted that almost all successful leaders draw on the same set of basic leadership practices. They organized these into four categories: (1) building vision and setting directions; (2) managing the program; (3) understanding and developing individuals; and (4) redesigning the organization. In changing the nature or style of AT service provision, attention to each of these areas by assigned administrators and AT leaders can be extremely effective in leading change and building agency capacity.

Documentation and Accountability

One way that AT service providers can serve as thought leaders is to document and report on the effectiveness of AT tools and AT services. Periodic meetings with supervisors foster leadership’s commitment to AT. End-of-year reports that include relevant data reinforce the professionalism of the AT team—even if it is a team of one! While there is increasing research about the effectiveness of a wide range of AT devices (See NATE Network website (www.natenetwork.org) for a list of research about AT), the field of AT has been notoriously negligent when it comes to documenting the effectiveness of AT services (Ranada & Lindstrom, 2019). Here are examples of how information may be included in the daily operations of AT teams:

Request for support. Traditionally, AT services have followed a medical model. Referrals for AT services often use a questionnaire that focuses on a detailed description of the student. This can sometimes be a case of information overreach and does not provide clarity about what the school team really needs to consider for a student in the context of the classroom. Asking questions about the needs of the team providing direct service to the student can yield more useful information. The HIAT (High Incidence Assistive Technology) team of Montgomery County Public Schools, Maryland, as part of an initiative to build capacity beginning in 2003, shifted from a medical referral to a survey form that requests a minimum of information on the student and focuses more on the needs of the school team. For an example of the type of questions included in the HIAT Request for Support, visit https://www.natenetwork.org/knowledge-base/differentiating-at-services-resouces/. While a Request for Support survey begins by requesting essential information such as the student identification number, school contact information, grade, etc., the survey focuses more on questions regarding the school team's comfort level with AT consideration using a Likert scale (not comfortable, somewhat comfortable, comfortable, very comfortable). More detailed information on the student is typically available in the district's online student database. The following are a few examples of questions on the form:

- How would you rate your team's ability to identify and prioritize critical barriers to learning for a specific student?
- How would you rate your team's ability to do the following tasks related to the AT trial process? (e.g., identify the barrier to learning, plan and implement a trial period)
- What is your knowledge of the following tools? (Tools available within the agency are listed)

This request for support communicates the important role of the school team in collaboration with the AT specialist. The survey taps into the school team's ability to consider AT and its knowledge of AT tools available in the district. It generates important data on the reasons for AT service requests and tool usage, which adds valuable context to an end-of-year report. Most importantly, it helps the AT team identify the appropriate starting point for AT support.

Tracking AT services. One way to measure AT services is to identify the nature of the services provided across the school year (e.g., support in using the SETT Framework, trial period support, AT tools consultation, assessment, AT training, equipment support, implementation plan support). An alternative to this is to track the intensity of AT services by measuring the number of hours of service provided (e.g., 1-5 hours, 6-10 hours, etc.). This data can be entered into the agency's student spreadsheet or database and is readily available for an end-of-year report.

Trial period data. The data collection described above is still only surface level information. Collecting data on the effectiveness of AT strategies and AT Team support is a more powerful reflection of the value of AT services. Unfortunately, the collection of AT usage data is typically hard to obtain, and collecting data that clearly isolates the effectiveness of AT on student performance is even harder. At a minimum, AT teams should collect the results of AT trials that typically involve four to six weeks of AT use. When AT teams provide trial period support, there should be an upfront, communicated expectation that a description of effectiveness must be sent back to the AT team. Periodic email reminders can reinforce this agreement. Trial period feedback leads to data on the outcomes of AT tools and strategies. A simple rubric can be applied to the description of the trial period results: a) the student is gaining skills in the use of a new tool or strategy; b) there was no improvement in student performance; or c) the student did not demonstrate a need for the targeted AT. This information can be added to the student database or spreadsheet.

AT services exit survey. Information on the effectiveness of AT tools and AT team support can be obtained through the use of a short, end-of-year survey. The survey can be sent to the contact person associated with each request for AT support. One survey question should address perceptions about student outcomes; a second question should address perceptions on staff outcomes. Staff outcomes data is critical and reflects capacity building. The third question should ask what more the AT team could have done to support the implementation of AT devices and services in the classroom. To keep the survey brief, logic branching can be used to expand responses. The exit survey form, if provided in a digital format, can automatically generate charts that can be included in an end-of-year report for questions one and two. For an example of the Exit Survey Form in an electronic format, visit https://www.natenetwork.org/knowledge-base/ideas-on-documentation-and-accountability-in-assistive-technology/.

End-of-Year report. The previous four examples of data collection can be built into ongoing, routine AT team procedures. This, in turn, can be included in an end-of-year report with very little expenditure of time. This report not only documents the work of AT service providers, but also serves as a history of the work of the team. AT teams, no matter how small, must demonstrate accountability. In addition to outcome data, this report can include information on professional development, resource and website development, and outreach efforts. It should also include goals and objectives for the following year and a review of current goals and objectives. The end-of-year report serves as a planning tool and an accountability report. It provides a process for using data to help identify areas for improvement. For an example of the End-of-Year Contents, which provides a list of what can be included in an end-of-year report, visit https://www.natenetwork.org/knowledge-base/documentation-and-accountability-resources.

Outreach to Stakeholders

AT service providers can also serve as thought leaders by building a network of AT support through outreach to other district stakeholders. Outreach involves seeing your team in the context of a larger system. It involves analyzing your role to problem solve larger systems issues. Outreach efforts attempt to build long term, mutually beneficial relationships with other departments and agencies that can address AT issues. Outreach often requires that AT teams move out of their comfort zone, and speak the same language as other educators. It is about not waiting to be asked; it is proactive rather than reactive. For example, periodic meetings with IT can yield discussions about tools that are needed to support a wide range of learners, as well as discussions about future technology tools and their accessibility features.

Reaching out to curriculum development staff can lay the groundwork to include more AT supports in the online curriculum. Accessibility supports might include digital classroom readings for use with text-to-speech tools; providing choices for how students can represent what they know, or developing a section where digital materials adapted for students with moderate disabilities can be shared.

Outreach to media specialists, individuals who traditionally operate school library and media programs, can result in everyday benefits. Media specialists are often keystones within a school. They are routinely tasked to evaluate and select educational materials, including instructional web-based subscriptions, and they often provide instruction on these tools. Many of these subscriptions have built-in accessibility tools. For example, some online encyclopedias have a variety of built-in supports (e.g. text-to-speech, dictionary tools, informational videos). Ensuring that media specialists are aware of these tools supports a wide range of learners within a school.

AT specialists are part of a larger system. It is ineffective to chase systemic problems one school at a time. Outreach is key to solving systemic issues. One way to develop an outreach plan is to use a graphic organizer or mind-mapping software to brainstorm all the issues affecting the implementation of AT within a district, and then link these issues to the stakeholders who can help solve systemic concerns. Working with supervisors to discuss stakeholder issues and make decisions on the best way to network should be an ongoing conversation. Networking helps to broaden AT providers' expertise. They learn about new initiatives and absorb the language in which to embed AT topics. They better understand their role in the context of student support. They develop relationships that can yield long-term benefits as staff move up to higher level positions within the organization. Outreach helps to position AT providers as thought leaders for students in the margins, while advocating for all students throughout the agency.

AT Team Toolbox

To remain a vital service and build AT capacity, today's AT specialists need two tool bags: one that includes AT and IT tools to support students, and another that helps teams increase the effectiveness and efficiency of AT services by building the skills and comfort level of classroom staff. There are many online tools available to make documentation easier, to market and deliver professional development, and to share AT resources, as well as to share AT success stories:

- File management tools allow teams to share documents.
- Spreadsheets allow teams to keep data on caseload and equipment use.
- Project and task management tools help teams communicate about team projects.
- Scheduling tools help teams set up meetings more efficiently.
- Marketing and social media tools provide a variety of ways to announce new products and professional learning.
- Survey forms allow teams to gather data.
- Professional development tools allow teams to use distance learning tools to reach a wider audience.

- E-learning tools provide a platform for mini courses and professional learning communities.
- Resource sharing tools allow teams to share popular AT tools and websites.
- Digital storytelling tools allow teams to share AT success stories.

For more specific examples of tools that increase the effectiveness and efficiency of AT services, visit the NATE Network website: AT Teams Professional Toolbox (https://www.natenetwork.org/knowledge-base/resources-for-building-at-capacity).

Going Forward

There will always be a need for AT proficiency, but AT services can and must evolve to meet changing educational and technological environments. AT specialists may be invited or assigned to serve on instructional teams or integrated into IT services, or be asked to serve on special projects. Whether a district has a dedicated AT team or whether AT specialists serve on blended teams, the fundamentals of AT are important—it is a unique and valuable expertise. AT Teams that remain isolated run the risk of being overlooked and undervalued if they do not make their contributions known. Building the AT capacity of school teams is the right thing to do for all learners, not just some learners in the margins. It benefits the system as a whole, and is consistent with current educational frameworks that embrace learner variability. It is imperative that we move the field of AT to be able to serve more learners. Moving increasingly toward a capacity-building model of AT service delivery involves change. It may lead to changing the way AT service providers think about their role; it may require courageous conversations. It is time to reenvision AT services to advance the practice of assistive technology and ensure that all students can become expert learners. AT providers and AT teams should examine their practices, agree on a direction for change, and use their vision as a starting place to begin the next evolution of AT services.

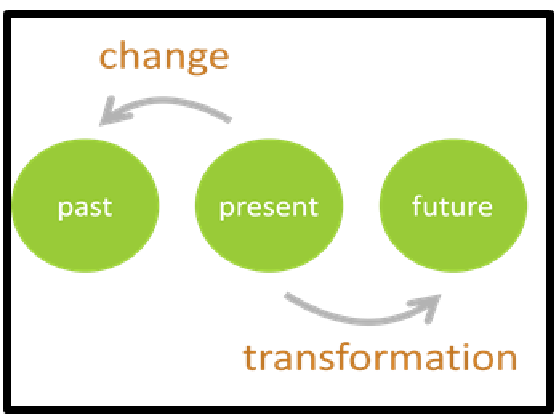


Figure 1: Change and transformation

Figure 1 illustrates two ways to go about defining a future state and a strategy to get there. The first is to stand in the present, look back at the past, and determine what to do. This usually results in improved outcomes and a more efficient future. The second is to stand in the present, visualize future opportunities divorced from the limitations of the past, and then start to create that future. The former cultivates change and is the good work of managers. The latter brings about transformation and is the work of leaders. It is only by declaring a future and a way of being (vs. doing) that groups and teams produce extraordinary results.

There is no right or wrong, good or bad, in these two approaches. The important thing is to be clear on what you are trying to do and then pick the right approach. If you want incremental change to AT service delivery, go with the first. If you want transformation in the way you approach AT in your district or state, get ready to let go of your fears, doubts, frustrations, disappointments, and everything else that could get in the way of dreaming big to build AT capacity—to enable the next evolution of AT services.

For information on professional learning to guide capacity building in assistive technology, go to https://www.natenetwork.org/at-teamwork/.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. Denise DeCoste has a limited financial and non-financial relationship with Don Johnston, Inc. in support of PAR/uPAR and The DeCoste Writing Protocol. Gayl Bowser has a limited financial relationship with CAST Publishing as co-author of *Leading the Way to Excellence in AT* and *Quality Indicators for Assistive Technology: A comprehensive guide to assistive technology services.*

References

American Psychological Association. (2018). *Effects of poverty, hunger and homelessness on children and youth.* Retrieved from http://www.apa.org/pi/families/poverty.aspx

American Psychological Association, Presidential Task Force on Educational Disparities. (2012). *Ethnic and racial disparities in education: Psychology's contributions to understanding and reducing disparities.* Retrieved from http://www.apa.org/ed/resources/racial-disparities.aspx

Assistive Technology Act, P.L. 105-394 (1998).

Bouck, E. (2016). A national snapshot of assistive technology for students with disabilities. *Journal of Special Education Technology, 31*(4), 183-194.

Bowser, G., & Reed, P. (2018). *Leading the way to excellence in assistive technology services: A guide for school administrators.* Wakefield, MA: CAST Professional Publishing.

Bowser, G., & Reed, P. (2012). Consultation, collaboration, and coaching: Essential techniques for integrating assistive technology use in schools and early intervention programs. *Journal of Occupational Therapy, Schools, & Early Intervention, 5*(1), 15-30.

Calderon, V. J., & Yu, D. (June 1, 2017). *Student enthusiasm falls as high school graduation nears.* Gallup Student Poll retrieved on June 10, 2018 from: http://news.gallup.com/opinion/gallup/211631/student-enthusiasm-falls-high-school-graduation-nears.aspx

DeCoste, D., & Bowser, G. (January, 2019). *The changing roles of AT teams.* Preconference seminar presented at the Assistive Technology Industries Association Conference.

DeCoste, D. (2014). *DeCoste Writing Protocol.* Volo, IL: Don Johnston Incorporated.

DeCoste, D., & Wilson, L. B. (2012). *Protocol for accommodations in reading.* Volo, IL: Don Johnston Incorporated.

DeCoste, D., Reed, P., & Kaplan, M. (2005). Assistive technology teams: Many ways to do it well. *National Assistive Technology in Education (NATE) Network*, Retrieved from www.natenetwork.org

Edyburn, D. L. (2000). Assistive technology and students with mild disabilities. *Focus on Exceptional Children, 32*(9), 1-24.

Individuals with Disabilities Education Act, 20 U.S.C. § 1400 (2004).

Kena, G., Musu-Gillette, L., Robinson, J., Wang, X., Rathbun, A., Zhang, J., Wilkinson-Flicker, S., Barmer, A., & Dunlop Velez, E. (2015). *The condition of education 2015* (NCES 2015-144). U.S. Department of Education, National Center for Education Statistics. Washington, DC. Retrieved from http://nces.ed.gov/pubsearch

Lammert, J. D., Johnson, L., & Fiore, T. A. (2015). *Conceptualizing capacity building.* Rockville, MD: Westat, Retrieved from https://osepideasthatwork.org/conceptualizing-capacity-building-0

Leithwood, K., Harris, A., & Hopkins, D. (2008). Seven strong claims about successful school leadership. *School Leadership & Management, 28*(1), 110-112 doi:10.1080/13632430701800060.

Michels, C. M. (2017). *The role of the assistive technology department in a special education cooperative.* (Unpublished doctoral dissertation, part 1). National Louis University, Milwaukee, WI. Author Contact Information: cmichels@nssed.org

Musu-Gillette, L., Robinson, J., McFarland, J., KewalRamani, A., Zhang, A., and Wilkinson-Flicker, S. (2016). *Status and trends in the education of racial and ethnic groups* 2016 (NCES 2016-007). U.S. Department of Education, National Center for Education Statistics. Washington, DC. Retrieved from http://nces.ed.gov/pubsearch

National Assistive Technology in Education (NATE) (2019).

National Educational Statistic Center. (2017). *Children and youth with disabilities.* Retrieved from https://nces.ed.gov/programs/coe/indicator_cgg.asp

Northouse, P. G. (2016). *Leadership theory and practice* (7th Ed.). Thousand Oaks, CA: Sage Publications.

The QIAT Leadership Team (2015). *Quality indicators for assistive technology: A comprehensive guide to assistive technology services.* Wakefield, MA: CAST Professional Publishing.

Quinn, B. S., Behrmann, M., Mastropieri, M., Bausch, M. E., Ault, M. J., & Chung, Y. (2009). Who is using assistive technology in schools? *Journal of Special Education Technology, 24*(1) 1-14.

Ranada, R., & Lidström, H. (2019). Satisfaction with assistive technology device in relation to the service delivery process—A systematic review. *Assistive Technology, 31*, 82-97, doi: 10.1080/10400435.2017.1367737

Reed, P. (1994). *Assessing students' need for assistive technology.* Oshkosh, WI: The Wisconsin Assistive Technology Initiative.

Reed, P. (2004). Critical issue: Enhancing system change and academic success through assistive technology: Themes from an outcomes summit. *Assistive Technology Outcomes and Benefits, 3*(1), 15-33.

Rowland, C., & Fried-Oken, M. (2010). Communication matrix: A clinical and research assessment tool targeting children with severe communication disorders. *Journal of Pediatric Rehabilitation Medicine, 3*, 319-329.

Technology-Related Assistance Act (Tech Act), P.L. 100-4007, (1988).

US Department of Education, Office of English Language Acquisition (January 2016). Fast facts: English learner (EL) trends from the nation's report card. Retrieved from https://www2.ed.gov/about/offices/list/oela/fast-facts/index.html

Woodward, J., & Cuban, L. (2000). *Technology, curriculum and professional development: Adapting schools to meet the needs of students with disabilities.* Thousand Oaks, CA: Corwin Press.

Wright, P. T. (2000). *Do co-ops make sense? An examination of special education cooperatives in Indiana.* (Doctoral dissertation). Indiana University. Available from UMI Microform (UMI No. 9981794).

Zabala, J. (1995). The SETT framework: Critical areas to consider when making informed assistive technology decisions. Retrieved from https://assistedtechnology.weebly.com/uploads/3/4/1/9/3419723/settshortpaper.pdf

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 111-128
 ISSN 1938-7261
Available online: www.atia.org/atob

Emergent Literacy for Students with Cortical Vision Impairment: Self-Directed Reading

Deanna K. Wagner, MS/CCC-SLP and Gretchen Hanser, PhD, MS, OTR/L[1]

[1]International Academy of Hope, New York City, NY

Corresponding Author
Deanna K. Wagner
1010 E. Glenn Dr.
Phoenix, AZ 85020
Phone: (602) 684-2953
Email: deannawagner@mac.com

Abstract

Students with Cortical Vision Impairment (CVI) struggle with literacy, including basic foundational knowledge. These students need comprehensive emergent literacy instruction which includes opportunities for self-directed reading. Self-directed reading simply implies giving students opportunities to choose a book and then explore it independently. In order to entice students to want to read, professionals need to have a wide assortment of personally meaningful and motivating books which are visually and physically accessible. This article will provide an overview of CVI, with very specific implications and suggestions for self-directed reading, along with a discussion of using PowerPoint to make books that are customized to meet students' vision needs.

Keywords: cortical visual impairment, emergent literacy, self-directed reading.

Target Audience and Relevance

This article is intended for use by professionals and families who are supporting learners with significant physical, communication, and sensory impairments. Our intention is to guide conversations across professional boundaries and encourage a multimodal collaborative approach. Our primary focus is on students who are identified or demonstrate characteristics of cortical visual impairments. The challenges with literacy learning may at first glance appear insurmountable for some of these students. Some well-intentioned interventionists have even gone so far as to re-define literacy in terms of symbolic representation of messages using objects or photos rather than the letters of the alphabet. In this article, we will define literacy as the ability to interact with text (letters of the alphabet) to produce (write) and understand (read) words. We will target emergent reading activities that can be self-selected and self-directed, as one element of comprehensive literacy instruction. Referencing the degree of impact from different visual characteristics can focus collaborative planning and specific ideas for finding and creating reading electronic materials. This article also includes specific ways that PowerPoint tools can address needs for using light, color, movement, and reduced complexity, to address common challenges associated with visual latency, visual field preferences, and absence of visually guided reach.

Introduction

Students with Cortical Vision Impairment (CVI) pose a daunting challenge to the professionals who are working to build students’ vision, communication, and literacy skills. Each professional brings his/her domain-specific expertise to the team, and may be looking at the student from a different perspective with different goals. It is essential that professionals share and integrate their expertise to design robust language and literacy instruction that is accessible and personally meaningful for these students. In this article, we will discuss ways in which robust emergent literacy learning can occur while also addressing students’ visual, expressive communication, and auditory processing needs in ways that don’t limit literacy learning. Some students may be overwhelmed by auditory information when attempting to engage visually, and by visual information when trying to listen to auditory signals. These are the students who we see putting their heads down when somebody reads to them, during shared reading. This may also occur during self-selected reading time. In some cases, they are compensating for a lack of ability to integrate vision and hearing, and basically “tuning out vision” is how they behave when listening hard (Dutton, 2015; Tietjen, 2019). We also need to be aware of auditory processing challenges and modifications that are necessary to provide meaningful literacy experiences for students who have combined vision and hearing loss (CVHL). In this article, we will discuss ways in which robust emergent literacy learning can occur while also addressing students’ visual and complex communication needs (CCN) in ways that don’t limit literacy learning.

Providing Appropriate Literacy Instructions

It is important for professionals to understand literacy development in order to design the most appropriate literacy instruction. The term emergent literacy describes the process of beginning, exploratory reading, and writing experiences of children before they learn to conventionally read and write (Teale & Sulzby, 1986). Emergent literacy is not about sight words, phonics instruction, spelling words, or taking comprehension tests—those are all conventional literacy skills. Instead, emergent literacy refers to the foundational experiences that prepare children for conventional instruction. It has been well documented that without a solid emergent literacy foundation, students will have difficulties with later conventional literacy learning. Professionals working with students with CVI need to understand the distinction between emergent literacy and conventional literacy in order to determine the most appropriate instruction. Although it is necessary to build a foundational knowledge base, emergent literacy is often poorly understood or not recognized as being important for students with CVI, particularly when these students have limited verbal language.

Emergent literacy starts at an early age, as infants, toddlers, and young children actively engage in a wealth of rich social interactions around print. Young children see print, experiment with print, and watch others use print. They are given opportunities to explore a wide range of books which they mouth, rip, flip, fan, hold upside down and pretend to read. Similarly, they are given a range of writing tools which they mouth, throw, and use to scribble. Children's early understandings and attempts are random, inconsistent, and fluctuate from day to day. Their attempts consist of culturally acceptable and expected errors which are celebrated. It is an implicit belief that students make errors and learn to problem solve as part of literacy development. Most importantly, emergent literacy is not readiness based; instead, it is based on the belief that all children are ready for literacy from a very early age—regardless of their level of understanding. Emergent literacy is a necessary base for all students—including those with CVI and limited expressive language capabilities.

The emergent literacy experiences of students with complex communication needs and cortical vision impairment are clearly different due to their verbal, visual, and physical challenges. They have clear gaps in their foundational knowledge and need comprehensive emergent literacy instruction. Erickson (2017) recommends the following daily activities for learners who are at the emergent literacy level: Shared Reading, Alphabet and Phonological Awareness, Independent Writing with the Whole Alphabet, Predictable Chart Writing, and Self-Directed Reading. While each of these areas is essential, self-directed reading is particularly challenging for students with CVI due to the high visual demands in books. Self-directed reading simply implies giving students opportunities to choose a book that they can explore independently. In order to entice students to want to read, professionals need to have a wide assortment of personally meaningful and motivating books which are visually and physically accessible. To provide solutions, this article will provide an in-depth discussion of CVI, CVI characteristics, implications, and suggestions for self-directed reading. Using PowerPoint to visually customize books will also be described.

Overview of Cortical Vision Impairment

Cortical Visual Impairment (CVI) is not an oculomotor issue but rather a manifestation of neurological impairment that impacts the processing of visual information. Roman (2018) has created a diagnostic framework for CVI along with guidelines for interventions and services that follow a strict set of medical and educational criteria. The framework defines how and why a student with CVI is demonstrating limitations in functional vision in order to be eligible for vision services from a teacher of the visually impaired (TVI). Lueck and Dutton (2015), with a different view, use the term Cerebral Vision Impairment to describe these students. In the textbook titled, Vision and the Brain: Understanding Cerebral Visual Impairment in Children, Lueck and Dutton (2015) describe the notion of a social-linguistic-conceptual framework. This framework describes a broader spectrum of brain processing that goes beyond the cerebral cortex to include areas of the primitive brain that involve reflexes and balance. The framework is based on the importance of fostering social interactions with the student to create personally meaningful experiences which ground visual learning. Although the terms Cortical Vision Impairment and Cerebral Visual Impairment are not interchangeable, for the purposes of this article, we will use CVI to refer to visual processing challenges that impact the potential for a child to interact in meaningful ways with educational materials and conversational partners.

In the past decade, knowledge about CVI has grown rapidly (Roman-Lantzy, 2018; Lueck & Dutton, 2015). CVI is frequently undiagnosed or unrecognized due to other manifestations of brain damage that result in multiple physical/cognitive impairments. There are also cases where the CVI is less severe and a student may be misdiagnosed as having autism, learning disabilities, or behavioral challenges.

Characteristics of Cortical Vision Impairment

According to Roman-Lantzy (2018), there are 10 characteristics of CVI that are measured by the CVI Range. The CVI Characteristics provide information about visual functioning and overall degree of impact in the following 10 areas: color preference, need for movement, visual latency, visual field preferences, difficulty with visual complexity, light gazing, difficulty with distance viewing, atypical visual reflexes, difficulty with visual novelty, and absence of visually guided reaching. Each of the characteristics can seriously restrict literacy learning. In order for students to build their literacy knowledge, professionals need to design literacy instruction in a manner that does not rely solely on students' vision. Overreliance on students' vision will restrict students' literacy development. There needs to be a balance between using literacy opportunities to teach students to use their vision versus accommodations for their vision so that students can go deeper with their literacy knowledge without having to be restricted by their vision. For the scope of this article, implications as well as solutions for self-directed reading will be shared. It is important to understand these so that the appropriate interventions can be designed. The Within-CVI Characteristics Assessment Method (Rating II) assesses the degree to which each of the 10 characteristics is interfering with a student's functional vision (scale of impact). Understanding students' Within Characteristics scores can help design literacy instruction. Based on students' degree of functioning within each characteristic, students are classified into a phase distinguished by levels of severity. Roman-Lantzy (2018, CVI Assessment) describes three phases of severity of CVI in her Score I on the CVI Range (across characteristics). Understanding the severity of visual impact has been used to offer differentiated interventions (Roman-Lantzy, 2019, Advanced Principles). See Table 1 for the description of the visual characteristics and progress monitoring for self-selected reading.

Table 1: Visual Characteristics and Progress Monitoring for Self-Directed Reading

Characteristic	Characteristic Severely Impacts Visual Function	Characteristic has a Moderate Impact on Visual Function	Characteristic Mildly Impacts Visual Function
Color preference	• Use audio books and printed books with favorite color tape as binding. • Visual books may use highly familiar single color objects on a black background.	• Provide books with a limited number of vivid, fluorescent colors. • Add color around the shape of 2D and 3D items in preferred color, including book elements (textbox, page turning arrows). • Experience/Memory books may also include tactile enhancements using preferred color.	• Provide books with images using in a variety of colors. • Continue with use of specific colors to guide looking at elements in the book (e.g., textbox, page turning arrows). • Ask for student input (preferred colors) when outlining shapes or text.
Need for movement	• Avoid reading in areas where shadows are cast by window blinds or near overhead fans. • Offer reading time while swinging or bouncing.	• Find a quiet space for reading that avoids distractions of movement in the background. • Use movement in to draw visual attention to book elements (text or textbox, page turning, moving or shiny image/item on the page).	• Continue to monitor visual distractions of movement in the background.
Visual latency	• To give students time to look at every page, adapt books with a switch that turns the page, that they can activate on their own time. • Continue to offer switch-adapted books even when the student turns the page quickly. Time to explore the effect is part of the learning process and may proceed looking.	• Be mindful of the effects of fatigue or over-stimulation when scheduling time for reading. • Don't expect the student to visually attend quickly when focusing on an auditory task (such as listening to the story being read). • When selecting a book, give students time to look at choices.	• Higher scores indicate latency is not a factor very often, and they can look at pictures (or text) in a book after the page is turned. • Visual elements on the page may need to be consistently placed or highlighted by color to remind students to visually shift focus to various areas of the page.
Visual field preferences	• Monitor field preferences when positioning a book, the person reading (or giving book choices), and the student.	• Avoid placing books or tablets flat on a table or lap tray due to lower visual field challenges.	• Students with CP almost never achieve a perfect score on this indicator due to challenges with lower visual field processing.

Characteristic	Characteristic Severely Impacts Visual Function	Characteristic has a Moderate Impact on Visual Function	Characteristic Mildly Impacts Visual Function
Difficulties with visual complexities	• Monitor visual complexity as it relates to objects, array, sensory environment, and faces. • Focus visual attention for choosing a book using a single-colored near object with no competing sensory inputs (including overhead lights).	• Offer electronic books with backlighting to improve visual processing. • Reduce competing sensory input as much as possible. • Be mindful that facial expressions are difficult to visually discriminate.	• Easy, familiar books are visually accessible even in busy environments. • Novel or more complex books should still be presented with limited competing sensory input.
Need for light	• Avoid reading in areas with possible targets for visual fixation (bright lights, fans, shiny reflective surfaces).	• Light can be used as a tool to engage/direct vision by presenting book choices on a light box or electronic stories on a back-lit tablet.	• Visual recognition or discrimination may be enhanced by backlighting, making repeated readings of the same book increasingly more enjoyable.
Difficulty with distance viewing	• Position books and book choices at a distance of less than 18 inches.	• Recognize that students may visually attend to large items as far away as 10 feet, especially if they are moving. • This is not sufficient vision to read independently when positioned in front of a large screen with a group of students.	• Higher scores indicate that distance is not a problem for this individual, as is rare for students with CVI. We should assume that reading books should take place using near vision when possible and without distractions of objects that are moving in the distance.
Difficulty with visual novelty	• Offer books with highly predictable auditory patterns, and/or predictable visual cues associated with moving to the next page.	• Include books with photos of familiar objects place in novel situations. • Use sentence frames to provide a stable context with only one visually different element on each page.	• Visual curiosity is an element of the drive to explore new books.
Absence of visually guided reach	• Don’t position a switch that turns the page of a book in a location that would require the student to look for it. • Rather than asking a student to reach for the book he/she is choosing, list the books and ask for a head nod or a vocalization as confirmation.	• Facilitate reaching to choose a book by adding bright or shiny enhancements. • Add reflective tape to the edge of the tablet to facilitate looking and reaching for the bottom edge of the screen to swipe right to left.	• Problems with visually guided reach may be minimized when we use eye gaze selection on a tablet or computer to click on an arrow that turns the page or a hot spot that speaks a message.

Characteristic	Characteristic Severely Impacts Visual Function	Characteristic has a Moderate Impact on Visual Function	Characteristic Mildly Impacts Visual Function
Atypical visual reflex	• Lowest score means the student doesn't blink in response to a quick poke at the area just between the eyes at the bridge of the nose (or other visual threat)	• Middle scores indicate the blink response to visual threat is inconsistent.	• Most students with CVI have an abnormal blink reflex. It is not something we target for educational interventions.

Note 1: Original Score Guide for Cortical Visual Impairment (CVI) Range Score II (Roman-Lantzy, 2018) is based on a 5-point rather than a 3-point scale.
0 = Full effect of the characteristic is present
0.25 = Behavior on this characteristic has begun to change or improve
0.5 = The characteristics is affecting visual functioning approximately half the time
0.75 = Occasional effect of the characteristic; response is nearly like that of individuals the same age
1 = Resolving, approaching typical, or response is the same as others of the same age

Note 2: Self-Directed Reading as defined by Erickson (2017) for students with severe disabilities is a recommended daily activity involving time selecting a book and interacting with the book.

Severe Impact from CVI Characteristics: Building of Visual Behaviors

Please note that although a CVI Range score may place a student in Phase I, it is important to carefully consider which of the CVI Characteristics is most critical for developing instructional accommodations and methods. Roman-Lantzy (2018, 2019) describes students in this phase as having difficulty using their vision to simply look at things.

Scoring guide according to Roman-Lantzy (2018), CVI Range Score II:

- 0 = Full effect of the characteristic is present
- .25 = Behavior on this characteristic has begun to change or improve

Lower scores in these areas may indicate that the student:

1. attends best to a single, preferred color and may not be able to visually engage with more complex materials. (Color preference)
2. attends primarily to movement, including being distracted by a ceiling fan. (Need for movement)
3. takes a long time to look at an item, every time it is presented. (Visual latency)
4. struggles with lateral visual fields, affecting where we might position a book (Visual field preferences)
5. can only focus visual attention on a single-colored near object when there are no competing sensory inputs, including lights overhead or from windows. (Difficulties with visual complexities — evaluated as it relates to objects, array, sensory environment, and faces)
6. attends to sources of light to the point of visual fixation and has trouble looking away from bright lights. (Need for light)
7. demonstrates best viewing is at a distance of less than 18 inches. (Difficulty with distance viewing)
8. prefers to look at items that are familiar and is not curious about new things. (Difficulty with visual novelty)

9. looks, looks away, and then reaches for an item, using separate rather than integrated actions. (Absence of visually guided reach)
10. doesn't blink in response to a quick poke at the area just between the eyes at the bridge of the nose, or other visual threat. (Atypical visual reflexes)

These are students who present as obviously severely visually impaired. If they appear to be looking at all, it seems like they are unfocused and looking "through" rather than "at" something. During reading activities, the student may not attend to the pages of a book or the person who is reading to them. In busy, loud classrooms, these students may appear unengaged or uninterested, and may tune out. Document changes in visual behaviors over time, as impact of CVI characteristics may decrease. CVI interventions may focus on teaching students to simply look at materials and people. Professionals using interventions to promote improved visual function typically present a familiar item that is brightly colored with a single color and placed on a black background devoid of complexity. Throughout the day, these students will need additional interventions to build joint attention through other channels, such as touch and movement. Students with this degree of severity have been observed to engage visually with objects that are in motion, or when they themselves are moving. Students with vision impairments and other multiple impairments are delayed not only in visually guided reach, but also with reaching for (and localizing to) a sound. Being able to reach for an object by sound (integrating/organizing motor experience) may be an indicator of readiness for independent/autonomous mobility (Fazzi, Molinaro, & Hartmann, 2015). Sensory-motor interventions may also incorporate rhythm and predictable sounds in order to build the students' abilities to localize and reach for an item by sound rather than sight. We need to plan for access to self-directed book reading opportunities that may be engaging/motivating to these students based on sounds or rhythm. See Table 2 for more ideas about self-directed reading as it relates to PowerPoint tools we can use to address CVI characteristics.

Table 2: Visual Characteristics and PowerPoint Tools for Self-Directed Reading

Characteristic	**Characteristic Severely Impacts Visual Function**	**Characteristic has a Moderate Impact on Visual Function**	**Characteristic Mildly Impacts Visual Function**
Color preference	• Slide Backgrounds black • Insert Photo with Transparent Background (Instant Alpha)	• Insert Photo • Use Glow	• Use Glow formatting • Insert Shapes with an opening in the middle • Insert Sound recording to the slide
Need for movement	• Transitions • Animations	• Order Animations • Time Animations	• Order Animations • Transition (page curl)
Visual latency	• Settings = Loop • Transitions on click	• Transitions on click • Animation Timing (sequential, pauses) • Links	• Transitions • Animations Timing (simultaneous)

Characteristic	Characteristic Severely Impacts Visual Function	Characteristic has a Moderate Impact on Visual Function	Characteristic Mildly Impacts Visual Function
Difficulties with visual complexities	• Insert Sound recording for each page • Setting = Loops • Animation to bring in a textbox as object • Timing Order after the inserted sound is played	• Adjust Brightness • Insert Photos with limited visual information • Delete image backgrounds (Instant Alpha or Transparent Background)	• Use Transparent formatting (Instant Alpha) of Objects
Difficulty with visual novelty	• Insert only one Sound (recording) per page	• Insert Photos of • Make Photo Background Transparent (Instant Alpha) • Duplicate PPT shows to create multiple versions of a similar story	• Use Transparent Background (shape) and Color • Draw or Markup photos • Insert Images of line drawings (symbols)
Absence of visually guided reach	• Use iPad Recipe “Turn Pages” for switch control	• Insert Shape of page turning arrow • Use Glow formatting to highlight edges • Animation Order bring in the page turning arrow only on click and after any recordings	• Consider use of eye gaze selection

Note 1: Original Score Guide for Cortical Visual Impairment (CVI) Range Score II (Roman-Lantzy, 2018) is based on a 5-point rather than a 3-point scale.
0 = Full effect of the characteristic is present
0.25 = Behavior on this characteristic has begun to change or improve
0.5 = The characteristics is affecting visual functioning approximately half the time
0.75 = Occasional effect of the characteristic; response is nearly like that of individuals the same age
1 = Resolving, approaching typical, or response is the same as others of the same age

Note 2: Self-Directed Reading as defined by Erickson (2017) for students with severe disabilities is a recommended daily activity involving time selecting a book and interacting with the book.

Meet Aaron. Aaron was born with cerebral palsy and it was clear immediately that he had trouble focusing his vision. Due to high spasticity, he wasn’t able to walk or use his hands to pick things up. But he was very interested in toys with buttons and sounds and lights. He does not attend visually to photos or symbols, and has even damaged communication devices with dynamic screens in his efforts to avoid looking at the screen. During free time at home and in preschool, elementary, and high school, he was happiest rolling on the floor and interacting with musical toys. He graduated high school last year and his joy in interacting with musical instruments persists. During his school years he learned to activate switch-adapted computer games and stories. He really enjoyed music therapy and would happily listen to stories about different musical instruments, various types of songs, and musicians. He was also amused by books with silly sound effects, alliteration, and rhyming words. He would laugh, smile, put his head down to listen and reach out to activate a switch to turn the page, using a big whole arm slapping motion. In high school it was discovered that placing the device behind him helped him to focus on listening without being distracted by the light from the screen. Visual characteristics of light fixation and difficulties with visual complexity were affecting his ability to use a dynamic screen communication device. In his Adult Day Program his team discovered his joyful response when somebody gave a dramatic reading accompanied by chanting and rhythm. As part of his ongoing private speech therapy services, we are continuing to adapt audio books for him, using the Pictello app on his iPad and his mom's phone (see Figures 1 and 2 for screen captures). He enjoys hearing different voices read the same story. He wears a speaker on his wrist to listen to stories and music.

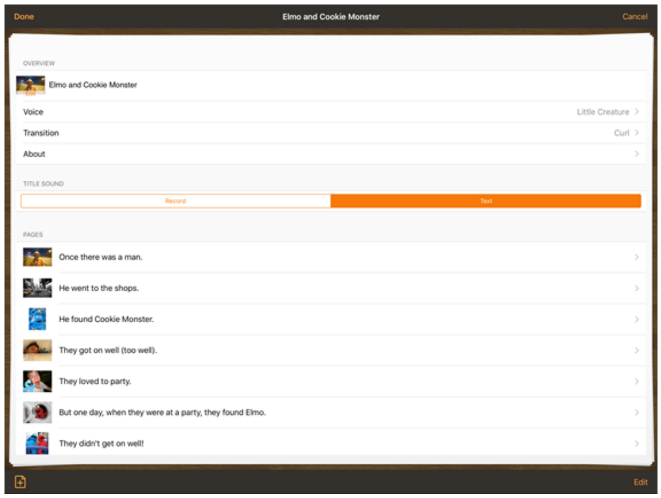


Figure 1: Elmo and Cookie Monster

This iPad screen capture shows thumbnails and page text for a story downloaded into the Pictello app, which has an option for the Little Creature voice. A link for more information about the Pictello app can be found [here](#).

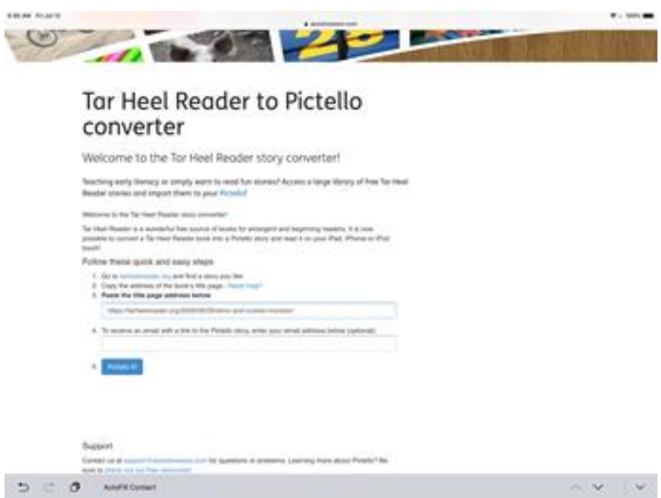


Figure 2: Tar Heel Reader to Pictello Convertor

This screen capture depicts how to convert Tar Heel Reader stories to the Pictello app. The link to this site can be found [here](#).

Moderate Impact of CVI Characteristics: Integration of Vision and Function

Students at this phase are learning to integrate vision with function. Higher scores on some of the rating scales indicates that the characteristics of CVI are not as debilitating as they are for students with lower scores. Recognizing the impact of visual latency as a CVI characteristic can be critical for reading books with these students. They may also need to figure out how to position themselves to address visual field neglect or preferences. We can make a significant difference in their ability to gain meaning from a book they choose to read (at the pace the student chooses to read it).

Scoring guide according to Roman-Lantzy (2018), CVI Range Score II:

- .25 = Behavior on this characteristic has begun to change or improve
- 5 = The characteristic is affecting visual functioning approximately half the time
- .75 = Occasional effect of the characteristic; response is nearly like that of individuals the same age

Lower scores in these areas may indicate that the student:

1. can attend to more than one color, though bright fluorescent colors may be most engaging, and may benefit from highlighting visual features of both 2D and 3D items in a preferred color. (Color preference)
2. can be visually distracted by movements 8 to 10 feet away. But we can also use movement to bring their attention to a particular area where they can focus on a specific item, such as elements on the page of a book. (Need for movement)
3. takes increasingly less time to look at something once it is familiar, but takes more time again when the person is fatigued, over-stimulated, or just after a seizure. (Visual latency)
4. can visually fixate on items in more fields, though lower visual field function may remain atypical. (Visual field preferences)
5. can attend to more details or more items at once, though competing sensory input is still visually distracting and using backlighting can engage vision. (Difficulties with visual complexities)
6. engages visually when light is used as a tool to direct vision, such as through use of a light box or back-lit tablet. (Need for light)
7. visually attends to items as far away as 10 feet, especially if they are moving, such as recognizing a person who is moving in the distance. (Difficulties with distance viewing)
8. demonstrates increasing visual curiosity, built from experiences with objects. Visual curiosity does not occur spontaneously with 2D images. (Difficulty with visual novelty)
9. looks and reaches in a more integrated manner, sometimes facilitated by use of bright or shiny/moving objects. (Absence of visually guided reach)
10. blinks in response to a visual threat inconsistently. (Atypical visual reflexes)

Giving a student time to figure out when they are ready to turn the page is part of advocating for personal choice. We cannot know how long a student needs to look at a page before it starts to make sense. We can do our best, however, to make modifications to the schedule and the environment to give the student all the time he/she may need. Tietjen (2019) cautions us to carefully consider the complexity of the reading task and the environment. Many students with cerebral palsy and CVI experience difficulty visually processing information presented in the lower visual field, impacting not only their mobility, but also their ability to look at a book placed flat on their lap tray. Students who are learning to integrate vision with function may also be learning visually guided movements, like reaching for a book while looking. We should not be discouraged if students are not looking when given choices, since at these levels of visual functioning, students may still be learning to do this. If the book piques their interest, we may open a window into what it takes for him/her to make the effort to overcome challenges that had been getting in the way of interacting with materials or people in more integrated and functional ways. Assessing CVI characteristics of complexity may be important in understanding how social relationships and joint attention can be impacted, since these students have difficulty visually processing faces and facial expressions. Since they cannot see other people smiling or frowning, they may not be emulating this behavior. See Table 2 for more ideas related to self-directed reading.

Meet Ben. He is six years old and is being raised by his grandmother due to his mother's challenges with drug addiction. When he was younger, his favorite color was yellow, but he visually attends to a variety of colors now and will use colors to talk about simple images in board books. He loves it when his grandmother reads to him. She makes sure the lights are low and gives him time to look at the pages, sometimes using a flashlight to draw his attention to something on the page. He will use his eye gaze communication system to ask her to read to him. Color is used on his communication displays to reinforce navigational branching. He has a page programmed with a number of his favorite stories and will also use the alphabet page in an attempt to request a new story by giving some letter cues. He likes listening to dramatic stories with repeated lines and predictable, controlled text. He is learning to activate some online stories with eye gaze control of his device. The button to start the stories is in a predictable place to be familiar enough to address his difficulties with visual complexity and challenges with visual novelty. Sometimes he looks at the screen, but more often he leans his head down and quietly listens.

Milder Impact from CVI Characteristics: Developing Visual Curiosity

A thorough understanding of the CVI characteristics is necessary in order to determine how to improve or address visual functioning of students with milder (Phase III) CVI. Some of these students are not identified as having CVI until they try to read on their own (Dutton, 2015). They may seem clumsy due to problems with visual-motor integration. They may seem grumpy or oppositional because they don't respond consistently to facial expressions or body movements of other people. Students who can speak may self-report that they can't read or don't like reading to themselves. More than likely, reading is seen as a difficult task because the items on the page are too visually complex. In order to help these students find books they like, we may be able to provide some continuity and consistency through the use of predictability and salient feature instruction.

Scoring guide according to Roman-Lantzy (2018), CVI Range Score II:

- .75 = Occasional effect of the characteristic; response is nearly like that of individuals the same age
- 1 = Resolving, approaching typical, or response is the same as others of the same age

Higher scores in these areas may indicate that the student:

1. does not require a specific color for visual engagement. (Color preference)
2. doesn't need movement to elicit visual engagement, but may still be distracted by movements in the distance while trying to look at the pages of a book. (Need for movement)

3. can look at a target when presented, and latency is not a factor very often. (Visual latency)
4. can visually fixate in most/all visual fields. Students with CP almost never achieve a perfect score on this indicator due to challenges with lower visual field processing. (Visual field preferences)
5. can attend to complex visual arrays even in environments with competing sensory in-put. (Difficulties with visual complexity)
6. may be able to visually recognize or discriminate better with backlighting, and may not have as many difficulties with visual fixations unless the person is tired, hungry, or immediately following a seizure. (Need for light)
7. doesn't have difficulty seeing at a distance, though a perfect score for students with CVI is rare. We should assume that reading books should take place using near vision when possible and without distractions of objects that are moving in the distance. (Difficulties with distance viewing)
8. is able to use vision to learn about new things. (Difficulty with visual novelty)
9. with motor impairments can visually attend to a target item as they are reaching for it. Problems with visually guided reach may be minimized when we use eye gaze selection on a tablet or computer. (Absence of visually guided reach)
10. has more typical blink reflexes, though all students with CVI tend to have atypical visual reflexes. It is not something we target for educational interventions. (Atypical visual reflexes)

Meet Cyntyhia. She has cerebral palsy and uses a dynamic screen communication device, an Accent from PRC-Saltillo, that she accesses through the same switches in her headrest that she uses to drive her wheelchair. She has some trouble with lower visual fields, and can be distracted by movements in the distance, making driving independently in noisy or crowded places an unrealistic goal. She also has some trouble visually recognizing obstacles in new environments. But she can safely navigate her home because it is familiar and her switch activations have become automatic after years of practice. When she was younger, her mother put pictures from stories on her bedroom ceiling for her to read to herself by advancing a slide projector with her switches. In high school, her speech therapist and vision specialist designed books for her to read with visually and conceptually salient features of the icons in her communication device. She directs her tutors and family members to read and review her schedule with her, one of the highlights of her day. As a young adult, she uses her switches to read back text documents sentence by sentence using her communication device, and follows a script to tutor a group of students who are learning to activate messages on their own communication systems.

Implications

The challenges with literacy learning may at first glance appear insurmountable for some of our students. Some well-intentioned interventionists have even gone so far as to re-define literacy in terms of symbolic representation of messages using objects or photos rather than the letters of the alphabet. In this article, however, we will continue to define literacy as the ability to interact with text (letters of the alphabet) to produce (write) and understand (read) words. The examples above highlight how each student has unique needs, but each can have daily opportunities for access to self-selected reading opportunities. Table 2 provides specific PowerPoint tools that may be used to support these students.

Creating Your Own Books Using PowerPoint

PowerPoint is an ideal solution for making books for students with CVI to be used during self-directed reading. PowerPoint is a readily available and highly flexible tool that can be used to visually customize books. PowerPoint has multiple features and tools which can be used to address the different CVI characteristics, such as adding color as an anchor, adding movement, highlighting salient features of texts and pictures, making onscreen occluders to reduce clutter, and adding audio recordings of salient feature descriptions. With specific knowledge of their students' CVI needs, professionals can select the most appropriate PowerPoint options for adapting books. Those who are looking for a collection of accessible books and ideas that can be downloaded into PowerPoint will find thousands of options on the Tar Heel Reader website here. Images from this website can be found in Figures 1 and 2.

When visual characteristic severely impacts visual function, consider these recommendations.

1. Use Black Color for Slide Backgrounds on all slides (see Figures 3 and 4 for examples). Books for building vision should use one item in a single color with a Transparent Background (see Figure 4).
2. Use Transitions between slides as a way to draw visual attention with movement. Use Animations to draw visual attention to a moving element on the slide.
3. Use Settings to make the slideshow Loop without exiting. Transitions and Timing support page-turning with individualized sensory feedback following a swipe or switch activation.
4. Create auditory-only books, using Insert Sound to add a recording for each page. Make sure that the PowerPoint loops when finished, and options to turn forward and backwards are included. Some students may notice a text box as an image if the complexity is reduced. Animation can be used to bring in a text box, Timing Order after the inserted sound is played.
5. Focus on auditory-only books. Insert only one Sound (recording) per page. Create memory books that are personally meaningful, possibly including the one item this student is willing to visually engage with. Consider printing the books so they can be read by other partners. Outline printed books in preferred color, possibly using reflective tape.
6. As a student starts to use vision more, his/her ability to reach and touch are not yet integrated. Students who are most severely affected tend to look, look away, and then reach for an item. While listening to a PowerPoint story, consider positioning a switch that turns the page in a place where the student would not need to look for it (e.g., behind his/her head, on a chest strap, or under his/her foot). Use iPad Recipe "Turn Pages" for switch control.

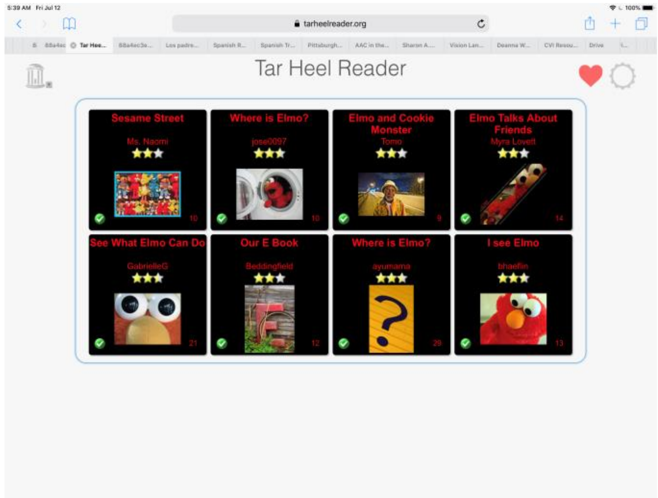


Figure 3: Tar Heel Reader Elmo Stories

Image depicts the thumbnails representing a collection of eight favorite Tar Heel Reader stories about Elmo with the background color set to black. Link to this page can be found [here](#).

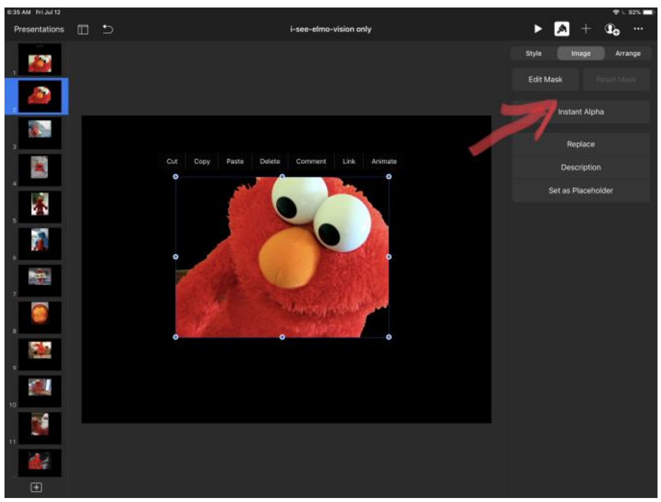


Figure 4: Elmo Vision Only Book

Image depicts a PowerPoint slide with a single image of Elmo, using black text and transparent background. A link to the full story can be found [here](#).

When visual characteristics moderately impact visual function, consider these recommendations.

1. Insert Photo of a familiar brightly colored object. Use Glow for words and/or objects in slides to color around the items in preferred color (See Figure 5).
2. Order Animations to draw visual attention and control pacing of movements on the screen.
3. Transitions and Timing support page-turning with individualized sensory feedback following a swipe or switch activation. Create a PowerPoint launcher that Links other stories or websites. (This requires clicking, not just swiping.)
4. Beware of distractions from competing sensory input. Consider how the backlight from a tablet engages vision, and adjust Brightness according to individual needs. Insert Photos with limited visual information. Delete backgrounds of objects with Transparent formatting.

5. Build visual curiosity starting with preferred or everyday objects and then Insert Photos of these objects using Transparent Background formatting. Create multiple versions of a similar story. Use familiar or repeatable lines as the context for learning to look when a page or a line is changed.
6. Students who have more functional vision may look and reach for items on a tablet/iPad when the item is shiny or moving. Consider Inserting a page-turning arrow Object in a preferred color with Glow formatting to draw attention. Use Animations to bring in the page-turning arrow only after the student has had an opportunity to visually attend to the image on the page and the text (or the audio recording). For students with physical challenges who cannot touch the page on a tablet, consider using this as a cue to touch the switch or use eye gaze dwell selection (mouse click) to activate the action on the page-turning arrow Object.

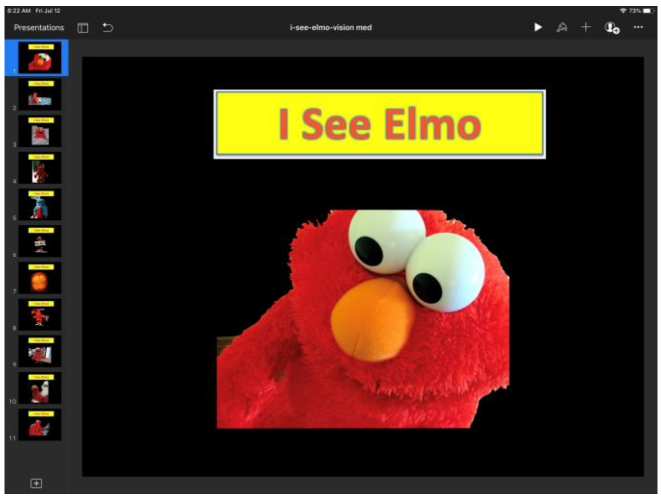


Figure 5: Elmo Animated

This version of the story uses an animated textbox example with glow coloring of the text. A link to the full story can be found [here](#).

When visual characteristics mildly impact visual function, consider these recommendations.

1. Use Glow formatting (with preferred color) on more complex images to build language of joint attention based on color concepts.
2. Insert Shapes (using preferred colors) as occluders to block out distracting portions of an image. Choose a circle or square with an opening in the middle. Use language to talk about what is inside and outside the shape during shared reading time (or Insert Sound recording to the slide). As indicated for more moderate levels of visual impairment, problems using visually guided reach may be minimized when we use eye gaze selection on a tablet or computer. Order Animations to draw visual attention to a new concept, with the focus on building language around the movements themselves. Use Transitions with movement to draw visual attention to page-turning.
3. If latency is not an issue, then Transitions and Animations can either occur in order after previous or after click.
4. Consider how background information may be unnecessarily distracting (visual or auditory). Use Transparent formatting of Objects as needed.
5. Use Transparent Background (shape) and Color formatting of objects as necessary to draw

attention to visual characteristics of new items that are related to familiar items. Consider using Markup of photos in another program/application before inserting. Insert Images of line drawings (symbols) to build familiarity with multiple representations of high frequency words.

6. As indicated for more moderate levels of visual impairment, problems using visually guided reach may be minimized when we use eye gaze selection on a tablet or computer.

Outcomes and Benefits

All students benefit from systematic daily emergent literacy intervention, regardless of their disabilities. Using the CVI characteristics to guide discussion provides teams with a framework for appropriate accommodations to maximize potential growth in reading abilities. The degree of educational impact from CVI characteristics can be systematically reviewed. The recommended PowerPoint tools can be used over and over again as a template to create a multitude of books and stories that are relevant and personally meaningful. Some animations that add an element of engagement for other students have potential to interfere with learning of a particular student based on their CVI. With PowerPoint, timing of auditory and visual elements can be ordered and manipulated. Once these students realize that they are in control of the rate of animations and transitions in a PowerPoint show, they can truly experience self-directed reading.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author(s) of this paper.

References

Brady, N. C., Bruce, S., Goldman, A., Erickson, K., Mineo, B., Ogletree, B. T., Paul, D., Romski, M., Sevcik, R., Siegel, E., Schoonover, J., Snell, M., Sylvester, L., & Wilkinson, K. (2016). Communication services and supports for individuals with severe disabilities: Guidance for assessment and intervention. *American Journal on Intellectual and Developmental Disabilities, 121*, 121-138.

Bruce, S. M., & Bashinski, S. M. (2017). The trifocus framework and interprofessional collaborative practice in severe disabilities. *American Journal of Speech-Language Pathology, 26*, 162-180.

Erickson, K. (2017). Comprehensive literacy instruction, interprofessional collaborative practice, and students with severe disabilities. *American Journal of Speech-Language Pathology, 26*, 193-205.

Fazzi, E., Molinaro, A. & Hartmann, E. (2015). The potential impact of visual impairment and CVI on child development. In Lueck, A. & Dutton, G. (Eds), *Vision and the brain: Under-standing cerebral visual impairment in children*, (pp. 83-104), Arlington, VA: AFB Press.

Lueck, A. & Dutton, G. (2015). *Vision and the brain: Understanding cerebral visual impairment in children.* Arlington, VA: AFB Press.

Roman-Lantzy, C. (2018). Cortical visual impairment: *An approach to assessment & intervention* (2nd ed). Arlington VA: AFB Press.

Roman-Lantzy, C. (2019). *Cortical visual impairment advanced principles*. Arlington, VA: AFB Press.

Teale, W. H., & Sulzby, E. (1986). Emergent literacy as a perspective for examining how young children become writers and readers. In W. H. Teale & E. Sulzby (Eds.), *Emergent literacy: Writing and reading* (pp. vii-xxv). Norwood, NJ: Ablex.

Tietjen, M. (2019). What's the complexity? In C. Roman-Lansky (Ed.), *Cortical visual impairment advanced principles*, (pp. 92-159). Arlington, VA: AFB Press.

Wagner, D. (2019, June 16). *Stories of ourselves: Building social-linguistic skills of learners with CVI* [web log comment]. Retrieved from http://aacgirls.blogspot.com/2019/06/stories-of-ourselves-building-social.html

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 129-134
Copyright ATIA 2020 ISSN 1938-7261
Available online: www.atia.org/atob

Enhancing Structured Literacy™ Instruction with Educational Technology

Sharon LePage Plante, CE/AOGPE

The Southport School

Corresponding Author
Sharon LePage Plante, CE/AOGPE
The Southport School
214 Main Street
Southport, CT 06890
Email: splante@southportschool.org

Abstract

Structured Literacy™ provides direct and explicit instruction to prepare students to decode words. The elements of the instruction include phonology, sound-symbol association, syllable instruction, morphology, syntax, and semantics. While traditionally presented in a one-to-one format, Structured Literacy™ Instruction is now entering small group instruction, and is not without some challenges. Managing word lists and flashcards that follow the lesson yet meet the individual needs of multiple students can be organizationally demanding. When working with a small group, it can be difficult to engage all students equally, as well as account for their various learning differences. The incorporation of educational and assistive technology can provide the educator with the ability to simultaneously engage students and account for differentiation of needs, while documenting progress. Furthermore, students benefit from instruction at their level and their pacing, and also learn strategies to enhance their use of technology for access.

Keywords: literacy, reading instruction, reading specialists

Introduction

Structured Literacy™ is the key to impact the gains in reading for students with learning disabilities. Based on neuroscience, this explicit linguistic instruction is essential for students with dyslexia. The lessons are systematic and cumulative, providing spiraling back of concepts for review while introducing new ones. Students are directly taught concepts and rules for sounds, syllables, and morphology. In addition to phonological awareness, students engage with fluency practice through oral reading and contextual reading to build comprehension skills. Lessons are diagnostic and prescriptive, with the teacher always assessing and adjusting the lessons to meet the students' needs. There is no direct scope and sequence, but rather a suggested path of skills that are adapted to meet each student's learning needs for decoding and encoding.

Reading has two components: The reading for the words, or decoding, and the understanding of what is being read, or comprehension. Students with learning differences may struggle with one area or both. Those who struggle with decoding often struggle with comprehension of print, as they work so hard to figure out what each individual word says that they cannot access the understanding of the text as a whole. For some students with dyslexia, the decoding skills may not be commensurate with their comprehension skills; thus, they are faced with the challenge of not being able to access and build on stronger comprehension of text. Structured Literacy™ provides the instruction to improve decoding and also continues to support the students' comprehension growth.

Traditionally presented in a one-to-one format, the push to get this vital instruction to those that need it has led to the Orton-Gillingham Academy embracing small group instruction with its Classroom Educator Certification. This move recognizes that not all educators and schools have the ability to build a schedule of one-to-one support. This shift to empower educators to provide Structured Literacy™ Instruction in small and large group settings maximizes delivery. Providing group instruction is effective for a broad range of learners while providing those with learning disabilities the systematic instruction that they need (Foorman & Torgesen, 2001).

Providing Structured Literacy™ Instruction in a small group can be challenging, however, due to the need to manage all the components in small groups, while also addressing differentiation. For new concepts and review of previously learned concepts, students read words and phrases aloud for practice and to demonstrate skill acquisition. Traditionally these words and phrases are written on flashcards and organized each lesson to provide a comprehensive review and individualized introduction to new patterns. Organizing flashcards and word lists for these words and phrases during group instruction can be difficult. There is a challenge to tracking each student's errors while keeping an active lesson and ensuring the differentiation of word choices. Providing individualized spelling reinforcement and assessment can be time-consuming. Fluency practice and contextual reading engagement are additional areas for time challenges and essential for providing at each student's level. Enter technology! Across the elements of Structured Literacy™ Instruction, technology-based tools can make planning easier for the educator and the learning more accessible for the student (Lindeblad et al., 2017). The tools for some students are necessary assistive technologies while others provide the teacher ease of differentiation, recording of student reading and spelling for data tracking, and multiple means of engagement. Additionally, for some activities, multiple students can be working simultaneously on individualized tasks within a lesson component.

The Southport School, where I work, is an independent school for students with language-based learning disabilities (i.e., dyslexia, dysgraphia, ADHD). We have always embraced the tenets of Structured Literacy™ Instruction, and 5 years ago we brought an Orton-Gillingham (OG) Fellow on to the staff. The Southport School Tutorial classes, which focused on Structured Literacy, were small groups. As an Orton-Gillingham Classroom Educator certified teacher, who also is the Chief Technology Integrator, I have used my understanding of these areas to collaborate with the OG Fellow on ways to incorporate assistive and educational technology to enhance this instruction.

Using Technology to Enhance Structured Literacy Instruction Phonological Awareness

Phonological Awareness is the key area to build a foundation for further skill instruction. Twenty-something years ago, after I was trained in the Wilson Reading System, a reading program based on the OG philosophy, one of my favorite tools was their magnetic letter tiles and boards. However, managing this with several students presented challenges: Tiles might get lost or mixed up, and often there were not enough letters to go beyond basic words. The Sound Literacy app is an iOS app that is a powerful digital version of those magnetic boards that takes it up a notch. Letters replicate and the tiles cover skills from basic sound manipulation to advance roots, prefixes, and suffixes. This tool is to be used in instruction so best on a teacher's device. The Sound Literacy app allows the teacher to customize the tile sets to match the needs of a particular student.

When working in small groups, reviewing concepts for reading and introducing new ones, differentiation for each individual learner is essential. With these concepts, one student may need to work with single-syllable words, while another can manage multi-syllabic ones. The words, phrases, and sentences can be varied for the complexity of meaning as well. Making flashcards for students can be an effective means of delivering a reading intervention in a one-to-one setting; however, managing flashcards can be challenging when working with groups. Teachers spend countless hours making new cards to meet individualized student needs. Sorting and storing these flashcards can be an organizational nightmare given time and space constraints.

Educational technology has been a game-changer for presenting individualized words within a concept with a group of students. A straightforward shift was to make a table in a document or slide presentation with a row for each student to read. Each row was then color-coded to the selected student's color and words inputted to match the student's level of work within the area of focus. By utilizing a document or a slideshow program, a table can be shared with student devices or projected, and students can read the words in their assigned colors rather than presenting one word at a time via flashcard. Color-coded tables can be used for phrases, sentences, and paragraphs as well, making it easier for the tutor to differentiate and not have to manage piles of cards. Additionally, the tutor can print out the table and mark errors for data tracking instead of trying to sort flashcards into relevant accuracy piles for each student in a group drill.

To further engagement and student sample collection, the tables can be exported as a PDF or with a screenshot and brought into Classkick. Classkick is a whiteboard-style educational technology tool that provides a blank canvas for building activities through text, voice, drawing, and images (see Figure 1). With the table being added to a Classkick slide, students are able to record themselves reading their assigned words. This eliminates the downtime for having one student reading at a time, helps those who don't like reading in front of others, and keeps the recording for review later or for sharing with parents. Classkick activities are shared to students via a code, so the tutor could also make different lessons for individual students or groups of students to be completed simultaneously.

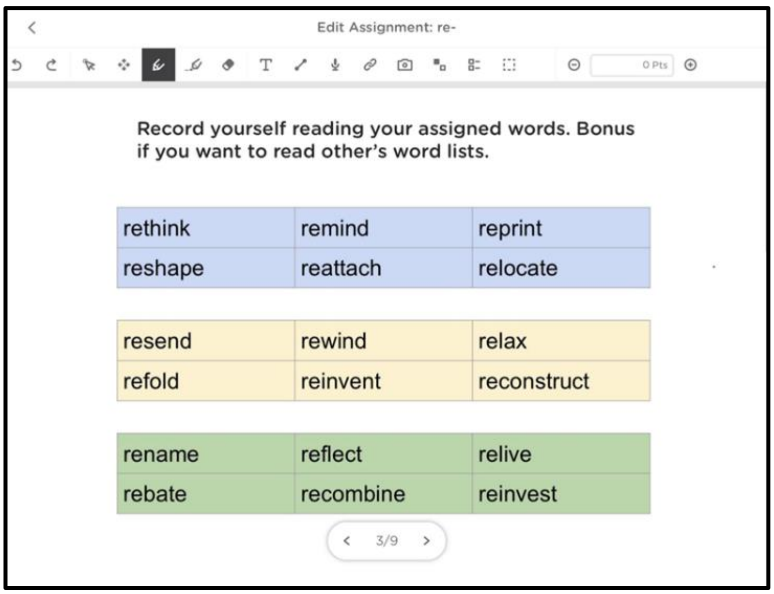


Figure 1: Example of colored coded tables made in a document, brought into Classkick.

Fluency

Assessing fluency has always been a task with its own challenges. Traditionally, this has been done as a one-to-one task, with the student reading aloud and the teacher with a clipboard, a copy of the text, and a stopwatch, trying to keep a running record. One difficulty is trying to accurately document errors made. Another is keeping examples of the student's reading for future review. A final challenge is what the other students are doing while the teacher is working with one student.

Fluency Tutor from TextHelp works within the Chrome environment, allowing educators to assign passages, and have students record and be provided feedback. An alternative that is web-based and can work on multiple platforms is Flipgrid, a video-based learning tool. The benefits of this educational technology positively impacted fluency for students at The Southport School (TSS). Through the use of

Flipgrid, students could simultaneously record themselves in privacy. As the teacher, I could review the recording as many times as needed and share with parents at conferencing. An unintended benefit was that students could hear themselves reading. At TSS, we found that when students listened to themselves reading aloud, they were better able to identify their own strengths and weaknesses. This led to significant improvements in fluency. Teachers reported that during informal assessments, they documented fewer errors and better prosody. In my classroom, students would review a passage as a class, then record themselves once a week for three consecutive weeks. They practiced during the week and then reviewed each previous recording to identify how they had improved as well as areas to continue working on, using a rubric. Additional tools that record audio to capture student reading include Classkick and Apple Pages and Keynote.

Spelling

When doing spelling practice, some students need words repeated due to auditory processing, working memory, attention, or other learning differences. Classkick can provide some solutions. With this educational technology tool, an educator can record themselves reading a word on each slide, and the student then can type or write the word on those slides. Students are able to listen to the word as many times as needed and work through the task at their own pace. The teacher, on their own device and in real time, can see each student's work as they progress. In doing so, the teacher can provide immediate feedback, as well as determine various stopping points as needed for individual students. This benefits slower processors who may be only able to complete 7 words, while another student could complete 15. Different sets can be made to differentiate words, and all students can be working on the task at the same time. One consideration is that if a student has word prediction available on their device, it is important to ensure that it is turned off before completing a spelling task. In true Structured Literacy™, handwritten words would be the ideal modality; however, given the co-morbidity of other disabilities such as dysgraphia, typing is the more accessible format for students to participate in encoding activities.

Contextual Reading

Contextual reading is also a key component of Structured Literacy™ Instruction. However, students' decoding levels may not be commensurate with their comprehension and interest levels. Educational technology tools such as Newsela, Freckle, and Rewordify can provide content sources for reading that can meet students' interests, while differentiating wording and vocabulary to meet decoding needs. Reading passages can be modified to meet each student's needs while allowing for all to participate in the discussion, because the essence of the article stays the same.

While not directly part of a linguistic lesson, having students read independently continues to support decoding skills, comprehension, and building vocabulary. Students who struggle with reading text often avoid any task of reading. Presenting this task for pleasure in auditory format can foster a joy of reading through an accessible format. This is not cheating (Wood, Moxley, Tighe, & Wagner, 2018)! When the goal is reading for understanding, material should be presented in a way that fosters accessibility. For those working to build decoding skills, traditional or eye reading is a challenge, while ear reading or the use of audiobooks or text-to-speech can open the door to the information, stories, and adventures. Think of the growth of audiobooks and podcasts; the world is embracing the engagement of our ears (Deniz et al., 2019). For those with print disabilities, two resources available are Learning Ally and Bookshare. Both have accessible texts that are available at low or no cost when documentation of a print disability is provided. Both work on a laptop or Chromebook browser. Learning Ally has its own iOS app, and Bookshare relies on third-party apps such as Voice Dream Reader or Dolphin Easy Reader. Voice Dream additionally has a scanner app allows the user to scan paper, and using optical character recognition, makes the paper accessible. The document can be exported to the Voice Dream Reader app to be read at another time or for repeated readings.

Summary

The growth of the implementation of Structured Literacy™ Instruction in schools is encouraging. Through the use of educational technology, educators can address some of the challenges related to utilizing this practice with small groups, easily address differentiation, and also gain documented examples of student work to demonstrate growth. Additionally, students can learn how educational technology can be an effective tool for access and engagement.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author(s) of this paper.

References

Deniz, D., Nunez-Elizalde, A. O., Huth, A. G., Gallant, J. L. (2019). The representation of semantic information across human cerebral cortex during listening versus reading Is invariant to stimulus modality. *Journal of Neuroscience, 39*, 7722-7736. doi: 10.1523/JNEUROSCI.0675-19.2019

Foorman, B. R., & Torgesen, J. (2001). Critical elements of classroom and small-group instruction promote reading success in all children. *Learning Disabilities Research and Practice, 16*, 203-212. doi:10.1111/0938-8982.00020

Lindeblad, E., Nilsson, S., Gustafson, S., & Svensson, I. (2017). Assistive technology as reading interventions for children with reading impairments with a one-year follow-up. *Disability and Rehabilitation: Assistive Technology, 12*, 713-724, doi: 10.1080/17483107.2016.1253116

Wood, S. G., Moxley, J. H., Tighe, E. L., & Wagner, R. K. (2018). Does use of text-to-speech and related read- aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *Journal of Learning Disabilities, 51*, 73-84.

Assistive Technology Outcomes and Benefits
Volume 14, Spring 2020, pp. 135-160
 ISSN 1938-7261
Available online: www.atia.org/atob

Emergent Literacy Instruction for Students with Significant Disabilities in the Regular Classroom

Erin Sheldon, M.Ed. and Karen Erickson, Ph.D.

Integration Action for Inclusion, Ontario, Canada

Center for Literacy & Disability Studies, University of North Carolina at Chapel Hill

Corresponding Author
Erin Sheldon
37 Inverness Crescent
Kingston, ON K7M 6P2
Canada
Phone: (613) 328-7632
Email: sheldon.erin@gmail.com

Abstract

Students with severe disabilities and complex communication needs face multiple barriers to participate in the general education curriculum. These students are often emerging in their language and literacy skills. They require comprehensive emergent literacy instruction long after their grade-level peers have become conventional readers and writers. Many educators struggle to provide this instruction in inclusive contexts, leading them to feel that school inclusion comes at the expense of effective instruction.

This article is Part 1 in a two-part series. Part 1 identifies some of the access and opportunity barriers these students face. Next, it describes a rationale for why the field of assistive technology should address these barriers. Finally, it summarizes the essential elements of comprehensive emergent literacy instruction. Part 2 goes on to describe a specific approach to service delivery that distributes comprehensive emergent literacy instruction across the school day, maximizing instructional time and improving access to quality instruction.

Keywords: inclusive education, comprehensive literacy instruction, AAC, severe disabilities

Introduction

This article begins with an anecdote that illustrates what comprehensive emergent literacy instruction can look like in a regular classroom. It then explores the barriers faced by students with severe disabilities and complex communication needs (CCN) when it comes to accessing general education curriculum. These are the barriers that accommodations like assistive technology can help remove. Next, it provides a rationale for inclusive education for students with severe disabilities and CCN. Finally, it describes the essential components of comprehensive emergent literacy instruction. This is the instruction that lays the foundation for reading, writing, and communication, preparing students for instruction in how to read with comprehension, write according to convention, and spell. Comprehensive literacy instruction is the central purpose of the general education curriculum; it can be the entry point to help all students meaningfully participate in the regular curriculum.

Samuel's Classroom

Samuel's 3rd grade teacher is reading aloud a chapter from the book, Charlotte's Web (White, 1952). Samuel sits with several classmates in the front corner of the classroom. When Samuel stirs restlessly, his peers remind him they are listening so they can describe the character of the rat, Templeton. A simple mindmap graphic organizer is in front of them, prompting them to write down words or ideas from the text that suggest key information about Templeton. Samuel's aide is observing this notetaking. She's made sure that Samuel's AAC is in easy reach, as well as a simple single message device. The single message device is recorded to say "that's it". The volume is off right now, but the click of the button when it is pressed is a cue that tells his classmates that Samuel heard something important that he wants written down on the graphic organizer. The students model its use, tapping the device before writing down their own ideas.

When the read-aloud is over, the class moves on to a writing assignment. Some students work in small groups or pairs, while others work independently. Samuel's small group starts work with a simple timeline graphic organizer to refresh their memories of what occurred in the chapter. Samuel's aide and classmates all use a version of Samuel's AAC to model their messages. Two students use a light-tech flipbook that replicates his high-tech AAC, while another has a duplicate of his AAC in an app on a spare tablet. The students demonstrate possible messages that restate and summarize the plot so far. They will post this timeline on a bulletin board their teacher will review with the class tomorrow before starting the next chapter.

Next, they move on to write a character description of Templeton. They brainstorm from the graphic organizer they used earlier to collect words that describe Templeton during the read-aloud. If a term does not appear in Samuel's AAC, they use their versions of his AAC to re-define it. For example, the students decide to restate "no decency" as NOT NICE. They use their AAC to help brainstorm terms that were not used in the text but that they can infer from the story, deciding he is often ANNOYING.

Samuel contributes to this list twice. First, as his peers scan through and consider the words from his

AAC, Samuel responds to BORING. One student asks if he thinks Templeton is BORING. Samuel responds with NOT. The students laugh and agree: Templeton is definitely NOT BORING! The second time, Samuel vocalizes when they consider the word “gluttonous.” They restate it as EATS TOO MUCH. Samuel does not seem satisfied with this and keeps touching his AAC. One of the student’s asks him if he wants GLUTTONOUS added to his AAC. Samuel laughs and smiles, looking up. Samuel’s aide interprets this as agreement and says, “I see you laughing, I think you are nodding yes.” They program GLUTTONOUS into his device while Samuel looks on with satisfaction.

Once they have consensus on a list of terms that describe Templeton, each student selects a term. They use a predictable chart writing process to compose complete sentences about Templeton, using the sentence stem, “Templeton is…” One classmate is the scribe for the whole group. She writes their sentences in a list:

- Templeton is lazy. (Ella)
- Templeton is greedy. (Ismael)
- Templeton is selfish. (Sara)
- Templeton is gluttonous. (Samuel)

Samuel makes his selection in response to partner-assisted auditory scanning. His classmates read aloud their list of brainstormed terms, and Samuel indicates his choice with the single message device, saying “that’s it” when he hears the word he wants. His sentence is, predictably, “Templeton is gluttonous.” One student is the most advanced writer in the group. She will rephrase their sentences to write a complete paragraph, using more diverse sentence structures.

Finally, the students reflect on whether they like Templeton. They use Samuel’s AAC to indicate their opinion, and why. Samuel surprises them by saying he LIKES Templeton. He is the only one of the four to express this opinion. His classmates use partner-assisted auditory scanning to read aloud his “like” words from his AAC. Samuel indicates he likes Templeton because he is FUNNY. This leads to a fierce debate, but Samuel’s opinion stands. As their teacher comes by the table, each student reads their sentences aloud. Samuel independently uses his AAC to say LIKE, and the debate about Templeton resumes.

As the lesson wraps up, Samuel’s aide snaps a photo of their group writing assignment to send home to his family. She expects that these sentences will be read and discussed tonight. She hopes she will have time later today to do more work with the chart of sentences, such as working with Samuel to turn it into a simple book for his tablet or laptop. For now, she adds the photo to the portfolio they keep of Samuel’s work. She smiles, already anticipating the moment that Samuel uses the term GLUTTONOUS in some unexpected context.

Barriers Faced by Students with Severe Disabilities

Samuel's team has found some effective solutions to the multiple access and opportunity barriers many students with severe disabilities face in regular classrooms (Beukelman & Mirenda, 2012). Access barriers are caused by the nature of the student's disability. These barriers are significant for students with severe disabilities. In contrast, opportunity barriers are caused by challenges outside of the student. Opportunity barriers reflect the policies, practices, knowledge, skills, and attitudes of our special education service delivery systems (Beukelman & Mirenda, 2012). Students with severe disabilities face as many opportunity barriers as access barriers.

Access barriers. Many students with severe disabilities and CCN enter school having not yet learned what most children learn incidentally in the realm of language and literacy. The knowledge and understandings that usually emerge in ordinary early childhood development are slow to develop for students with severe disabilities and CCN, due to challenges such as:

- sensory impairments (e.g., poor visual and/or auditory acuity);
- sensory processing impairments (e.g., cortical visual impairment or disruption to the vestibular sense);
- communication disorders (e.g., an inability to produce speech or difficulties processing symbolic language);
- memory impairment (e.g., reduced working memory, poor memory retrieval);
- cognitive impairment (e.g., slower rate of learning new concepts, difficulty integrating knowledge);
- physical disabilities (e.g., impaired motor skills or difficulties with motor planning).

Students with the most severe disabilities may experience several or even all of these disabilities simultaneously (Kearns et al., 2011). Many of these disabilities prevent students from learning incidentally or through ordinary exploration and imitation in early childhood.

Most students with severe disabilities learn at a slower rate. They struggle to acquire, maintain, and generalize skills. They need to be taught foundational knowledge, skills, and concepts, along with the strategies to recognize how and when to apply that knowledge in ordinary life. They require significant accommodations to remove their specific access barriers in instruction, materials, and assessment. These accommodations generally require "extensive, repeated, individualized instruction and support, substantially adapted and modified materials, and individualized methods of accessing information to acquire, maintain, generalize, demonstrate and transfer skills across settings." (Erickson & Geist, 2016, p.187)

Language development is often the most significant access barrier for students with severe disabilities. Many have complex communication needs. They do not have sufficient verbal speech to meet their face-to-face communication needs. About 1/3 of students with severe disabilities have no or limited use of symbolic communication (i.e., speech, signs, or symbols; Kearns et al., 2011). Up to 10% of these students lack a clear, understandable form of intentional communication, even by the time they reach high school (Erickson & Geist, 2016). Most would benefit from assistive technologies to augment verbal speech, provide alternatives to speech, and support their receptive understanding. Throughout their school careers, these students are often emerging in their understanding of language and literacy, including the technologies we use to communicate, read, and write.

Symbolic language and literacy skills develop in tandem in these students (Hanser & Erickson, 2007). Their skills in expressive communication (e.g., speech and its alternatives) emerge alongside their skills in receptive communication (e.g., listening and comprehension). Each new communication skill fosters new skills and understandings of how language can be expressed and represented in print, through reading and writing (Koppenhaver et al., 1991). Similarly, symbolic language development has an equally positive, reciprocal relationship with cognitive growth, fostering abstract and conceptual learning (Kearns et al., 2011).

These access barriers reflect the nature of the student's disability. They are the symptoms of the disability itself. They are the barriers that are often the focus of attention for students with severe disabilities and CCN, but they are not the only barriers that must be addressed. To help students with severe disabilities and CCN achieve the most positive outcomes, opportunity barriers must also be addressed.

Opportunity barriers. Students with severe disabilities and CCN face many potential opportunity barriers. These include the amount of time devoted to instruction, the type of instruction, and the instructional goals of that instruction. Opportunity barriers also result when educators do not have the knowledge, skills, technology, and dispositions required to provide all students with an opportunity to learn and interact during effective literacy instruction. Removing opportunity barriers is a central goal of assistive technology. As one aspect of special education service delivery, assistive technology is an accommodation of a student's disability that increases opportunity to learn. Legislation such as the Americans with Disabilities Act (1990) mandates that accommodations should remove barriers to participation, not impose them. Accommodations are meant to be the ramp that provides opportunity for participation.

In order to receive an appropriate education and access the regular literacy curriculum, students with severe disabilities need significant accommodations (Kearns et al., 2011; Lee et al., 2010; Towles-Reeves et al., 2009). Access to augmentative and alternative communication (AAC) systems is one essential accommodation for students with severe disabilities and CCN. Kearns et al. (2011) discovered that, on average, only half of students with severe disabilities and CCN who are pre-symbolic have access to AAC technology. This access to AAC varies considerably across states, ranging from as low as 24% to a high of 77%. Access to AAC is an important predictor of whether students with severe disabilities and CCN will become symbolic communicators by secondary. In their multi-state survey, Kearns and colleagues found that states with the highest rate of AAC access had the most students who had become symbolic communicators by secondary. States that failed to provide AAC were the most likely to have the same numbers of pre-symbolic communicators in secondary as they had in elementary.

While many students with severe disabilities have no symbolic communication, "the lack of symbolic communication in these students does not reflect the students' inability to acquire symbolic communication, but rather a lack of access to effective communication technologies and systematic instruction to use them" (Kearns et al., 2019). The biggest opportunity barrier faced by students with severe disabilities is the presumption that they do not require the same comprehensive instruction that non-disabled students need to develop their communication, language and literacy skills. Access to AAC is essential to address opportunity barriers for many students with severe disabilities and CCN. It is one of many forms of assistive technology that is essential to maximizing opportunities to learn for students with severe disabilities and CCN.

Barriers to Inclusion in General Education Settings

Many educators assume that some students are "too severe" for placement in an inclusive setting. However, the evidence does not support the notion that students' level of disability and access needs determine where they can be successful. The biggest predictor of whether a student with severe disabilities is educated in an inclusive classroom is not their functioning level; it is their zip code. More specifically, it is the specific school district the student lives in (Brock & Schaefer, 2015). This suggests that the barriers to inclusion itself are not intrinsic to the student's disabilities, but are instead opportunity barriers. Access to participation in regular school spaces is currently limited to those students who happen to live within school systems that have committed to removing the students' barriers to participation.

Few students with severe disabilities and CCN have access to a team like Samuel's or any access to general education settings at all. Over 90% are served primarily in self-contained settings (Brock, 2018), and less than 5% are served in general education settings at least 80% of the time (Kleinert et al., 2015). Regardless of where they are placed, the Individuals with Disabilities Education Act (IDEA) in the US mandates access to the general curriculum for all students with disabilities (IDEA, 2006 34 C.F.R.). Furthermore, a recent Supreme Court ruling (Endrew F v Douglas County School District Re-1, 137 S. Ct. 988, 2017) set important new requirements. Students must have an opportunity to meet challenging objectives aligned with grade level standards. Their individualized education programs (IEPs) must be both meaningful and appropriately ambitious, given each student's circumstances, so that each student has an opportunity to make more than minimal progress from year to year.

Inclusion is the result of delivering special education services within regular classroom spaces in a way that fosters students' ability to access regular activities and quality instruction while ensuring that students make meaningful progress from year to year. Effective inclusive educators prioritize changes in special education service delivery to support access to quality literacy instruction in inclusive settings. In doing so, these changes support physical access to regular spaces, participation in the community, learning progress within the regular language arts curriculum, and positive long-term outcomes for students with severe disabilities (Quirk et al., 2017. The overwhelming evidence from the past 40 years concludes that students with severe disabilities demonstrate better long-term outcomes when educated in regular classrooms (Copeland and Cosbey, 2009; Jackson et al., 2008; Ryndak et al., 2012). Table 1 summarizes the evidence for outcomes related to foundational communication, language, literacy skills and understandings.

Table 1: Effects of Inclusive Education on Students with Severe Disabilities

When compared to their peers in separate special education settings, students educated in inclusive settings:	**Source of Evidence**
demonstrate improved long-term outcomes, such as greater likelihood of competitive employment, greater choice in housing, and stronger measures of self-determination.	Carter, Austin, & Trainor, 2012 Jackson, Ryndak, & Wehmeyer, 2008 Ryndak, Hughes, Alper, & McDonnell, 2012 Wagner, Newman, Cameto, & Levine, 2006 Wehmeyer & Palmer, 2003
demonstrate greater overall success in school, including academic, social, and behavioral areas.	Bui, Quirk, Almazan, & Valenti, 2010 Feldman, Carter, Asmus, & Brock, 2016 Ryndak, Jackson, & White, 2013 Ryndak et al., 2010 Sauer & Jorgenson, 2016 Wagner, Newman, Cameto, & Levine, 2006
demonstrate more progress in academic content.	Cosier et al., 2013 Kurth & Masergeorge, 2012 Lee, Wehmeyer, Soukup, & Palmer, 2010 Soukup, Wehmeyer, Bashinski, & Bovaird, 2007
receive more instructional time and more individualized attention.	Kurth & Mastergeorge, 2012 Lee, Wehmeyer, Soukup, & Palmer, 2010 McDonnell, Thorson, & McQuivey, 2000 Soukup, Wehmeyer, Bashinski, & Bovaird, 2007
are exposed to more academic and literacy instruction.	Bowder et al., 2006 Ruppar, Fisher, Olson, & Orlando, 2018
learn foundational literacy skills and make progress in the general English Language Arts curriculum.	Bailey, Angell, & Stoner, 2011 Browder et al., 2006 Buckley, Bird, Sacks, & Archer, 2006 Dessemontent, Bless, & Morin, 2012 Dessemontent & de Chambrier, 2015 Mims, Lee, Browder, Zakasm & Flynn, 2012 Ryndak, Morrison, & Sommerstein, 1999
develop stronger communication and language skills when they are included in general education classrooms.	Calculator, 2009 Fisher & Meyer, 2002 Ganz, Rispoli, Mason, & Hong, 2014

Students with Severe Disabilities and the Regular Literacy Curriculum

Students with severe disabilities and CCN are frequently presumed unable to profit from exposure to literacy instruction and a rigorous academic curriculum (Durando, 2008; Katims, 2000). Special education teachers often rely on a student's cognitive ability, readiness skills, and communication skills to determine the potential value of literacy instruction (Ruppar et al., 2011). Attitudes about the potential for students with severe disabilities to become literate are a major opportunity barrier, as is the decreased emphasis on literacy in general, and increased emphasis on "functional" approaches to literacy (Browder et al., 2006) that accompany placement in separate settings.

Placement in separate special education settings is one factor that keeps students with severe disabilities from accessing comprehensive literacy instruction, such as that provided to students in the general education setting. This placement in separate settings often comes with “functional” approaches to literacy instruction that remove literacy skills, behaviors, and understandings from the broader context of communication and text comprehension (Erickson et al., 2009). These “functional” approaches focus on teaching isolated skills with drill and massed practice, using rote teaching strategies (Browder et al., 2006; Joseph & Seery, 2004; Katims, 2000). The result is that literacy skills for students with severe disabilities lag behind what would be predicted given their ability level (Channell et al., 2013), with only 20% reading more than basic sight words (Towles-Reeves et al., 2009).

If separating students with severe disabilities and focusing on “functional” reading skills resulted in improved literacy skills and improved quality of life and participation in their communities, then the evidence of the past 40 years would demonstrate that. Generations of students with severe disabilities would have left school with the language and literacy skills they needed to communicate effectively with others, and to use and access a variety of texts. Unfortunately, they have not. Instead, students with severe disabilities in inclusive settings are ten times more likely to be exposed to comprehensive literacy instruction than students in separate settings (Ruppar et al., 2018). As a result, students who are included in regular classrooms demonstrate stronger foundational skills in literacy than their peers in separate classrooms (Dessemontet & de Chambrier, 2015), and they have improved long term outcomes post-school (Ryndak et al., 2012).

Comprehensive Literacy Instruction

The regular English language arts curriculum is comprehensive (Pressley & Allington, 2014). It teaches students to speak, read, and write for a wide variety of purposes. General education provides a language- and print-rich environment where students are taught word reading, written language comprehension, fluency, writing, and all of the problem-solving and thinking skills required to use literacy across contexts. Literacy instruction for students with severe disabilities and CCN should be equally comprehensive (Erickson, 2017). It must address all components of instruction that are necessary for students without disabilities to learn to read and write (Allor et al., 2010; Erickson et al., 2009). Our instruction must integrate reading, writing, language, and communication in a way that is interactive and engaging. Along the way to conventional reading and writing skills, students should be engaged with a wide variety of high-quality texts, as they develop concepts of print, word identification, and alphabetic and phonological awareness (Erickson, 2017). Educators can accomplish this by pairing evidence-based instructional routines with the appropriate assistive technologies to address barriers and teach communication, language, reading, and writing.

Most students with severe disabilities are emerging in their understandings of how and why we use language and print (Towles-Reeves et al., 2009). They are developing phonological and alphabet awareness. They may not yet realize that when we read a book together, we are speaking aloud the words that appear on the page. Some are only just becoming aware of print or just beginning to attend to language. Others are becoming familiar with the tools and purposes of literacy, such as books, magazines, computer screens, keyboards, and pens. Many still need to develop a self-identity as someone who could comment, ask questions, share a story, or read a book. Comprehensive emergent literacy instruction addresses all of these things and invites students to join what Kliewer (2008) refers to as "the literacy flow."

Comprehensive emergent literacy instruction is intended to help students simultaneously develop: (a) understandings of the concepts and purpose of print; (b) phonological awareness; (c) alphabet knowledge; (d) language comprehension and vocabulary; and (e) the skills necessary to communicate with others about reading and writing.

Erickson (2017) describes six evidence-based interventions that can be used in combination to provide comprehensive emergent literacy instruction to students with severe disabilities and CCN. Each is described in Table 2 along with details regarding the student and adult roles and the expected student outcomes. The six interventions described by Erickson (2017) and summarized in Table 2 combine to provide evidence-based, comprehensive instruction. All six interventions remove barriers to participation in the regular English language arts and literacy curriculum when students are provided with the appropriate support to participate. Below, each of the six routines is described briefly with examples of the ways that assistive technology can remove the access and opportunity barriers inherent in each.

Table 2: Comprehensive Emergent Literacy Interventions

Intervention	The student's role	The adult's role	Expected outcomes
AAC modeling: communication partners demonstrate the use of the symbol system that we expect the student to learn to use	☐ Observe and attend to a model of how their AAC could be used. ☐ Respond and engage to interesting instruction in multi-modal ways. ☐ Explore possible messages and how messages can be generated. ☐ Notice and accept invitations to express a message. ☐ Initiate messages.	☐ Demonstrate use of the student's AAC, usually by directly pointing to visual symbols that represent words. ☐ Emphasize high-frequency messages and words. ☐ Model possible messages with no requirement to imitate or repeat the message. ☐ Attribute meaning to the child's communicative behaviors.	Improved: • symbolic language. • ability to combine and recombine symbols for different purposes. • self-identity as a communicator who can comment, complain, ask questions, and share ideas with others.
Shared reading: a more skilled other reads texts with the student, with a focus on fostering genuine interaction rather than simply page-by-page read-alouds.	☐ Increase engagement and participation in the reading process. ☐ Communicate with the reading partner about the reading experience and the text itself. ☐ Direct the reading process by selecting texts, commenting, and "bossing" the reading partner.	☐ Provide multiple daily opportunities to read aloud with the student. ☐ Comment and respond to the student. ☐ Invite participation and interaction with the text. ☐ Label items of the page. ☐ Connect the text to the student's life. ☐ Reference the print itself. ☐ Select engaging texts. ☐ Read texts multiple times.	Improved: • knowledge of books and a love of reading. • familiarity with the tools and routines of reading. • awareness of print. • expressive language and receptive vocabulary. • phonological awareness.

Intervention	The student's role	The adult's role	Expected outcomes
Shared writing: a more skilled other provides a scaffold to support the student to generate their own text, replicating the experience that non-disabled children have when an adult scribes their story.	☐ Participate in generating text by contributing their own ideas. ☐ Attend to highly predictable sentence structures that reflect their personal interests. ☐ Attempt to read, reread, and rebuild sentences. ☐ Focus on individual words within sentences.	☐ Elicit the student's attention and participation in generating text. ☐ Identify a meaningful sentence stem and choices to complete it that are meaningful to the student. ☐ Provide frequent opportunities to share and (re)read the student's text. ☐ Scribe the student's ideas.	Familiarity with the routine of shared writing. Improved: • awareness of print and sentence structure. • concept of word. • understanding that writing conveys meaning. • word identification skills. • self-identity as a writer.
Alphabet instruction: student is taught the names and forms of letters of the alphabet, along with the sounds these letters represent.	☐ Observe the use of letters in context. ☐ Explore letter selection and writing tools. ☐ Notice "important-to-me" letters in print. ☐ Explore personalized alphabet materials, such as alphabet books. ☐ Participate in naming and recognizing the letter form and sound(s).	☐ Provide short daily lessons with explicit, targeted alphabet instruction. ☐ Teach letter names, upper- and lowercase forms, the sounds each letter represents, and their use in text. ☐ Demonstrate how the letter is written or selected. ☐ Emphasize "important-to-me" letters, such as letters in student names. ☐ Provide repetition with variety in alphabet instruction.	Improved: • understanding of the alphabetic principle. • letter name and letter shape (upper- and lowercase) recognition in isolation and in text. • awareness of letter sounds. • ability to produce or select letter forms.
Independent reading: student independently explores reading materials and a range of texts	☐ Independently explore, handle, and attend to texts in various forms. ☐ Develop preferences for different genre or text types and for specific books. ☐ Sustain attention to texts.	☐ Provide daily opportunities for students to independently engage with a range of texts. ☐ Provide a large library of accessible texts, including digital texts and text readers. ☐ Read books aloud with eagerness and enthusiasm.	Improved: • understanding of why we read. • desire to learn how to read. • self-identity as a reader. • ability to access and select books and texts. • ability to sustain attention during independent reading.

Intervention	The student's role	The adult's role	Expected outcomes
Independent writing: student independently explores writing tools, generating text with letters of the alphabet	Explore, engage, and experiment with writing tools. Select or produce letters and words to convey a message. Observe demonstrations of how experienced writers select or produce letters to form words and messages.	Provide frequent demonstrations of how we use writing tools. Provide a range of writing tools, including keyboards, alphabet boards, and other alternate pencils. Use think-alouds to make the writing process visible and observable. Provide frequent, authentic daily opportunities to write. Maximize opportunities to share and read student writing. Provide feedback on the content or topic of student writing. Celebrate student writing. Encourage students to write more.	Improved: • ability to select a topic and generate ideas related to it. • understanding that letters form words and convey meaning. • ability to apply knowledge of letters, letter sounds, and print to generate text. • understanding of why we write and the purposes it serves. • self-identity as a writer.

For detailed information regarding how to implement each routine, see the webinars at InclusionOntario (https://www.inclusionontario.ca/Emergent-Literacy.html) and the professional development modules at Project Core (http://project-core.com).

AAC modeling. AAC modeling is a strategy where adults and peers demonstrate how an AAC system works in ordinary face-to-face communication (Biggs et al., 2018). The adult or peer indicates symbols in the AAC system while speaking with and interacting with the student with CCN. Adults and other communication partners attribute meaning to the student's communicative attempts and reflect back possible messages while selecting key words on the AAC system, such as commenting "I see you smiling, I think you LIKE it! I LIKE it, too." These responsive demonstrations of AAC use during interesting activities invite students to engage and interact with language. AAC modelling should occur all day, every day. AAC modelling often includes directive language, but should be balanced with the open-ended, playful, and emotionally affirming interactions that build language skills in all children (Hart & Risley, 1999).

Students with severe disabilities and CCN experience an impoverished language environment when they lack access to both AAC and to AAC modelling. Without AAC, and demonstrations of how to use it, students with CCN observe speech as it is spoken to and around them, but lack access to a model of language they can observe, explore, imitate, and attempt to use. These students may not otherwise produce sufficient speech to interact symbolically with others, restricting their language development. AAC modelling ensures every student has access to a symbol-based means of communication and interactive models of how to use it.

AAC modelling removes opportunity barriers by creating an immersive, dual-symbol language environment. The symbols in the AAC system are paired with spoken language to indicate their shared meaning, and their use is demonstrated by others in reciprocal and rewarding interactions. The student is invited to use this shared symbol system with communication partners, replicating the experiences that develop language in speaking children. In addition, the student observes communication partners demonstrating various of Light's (1989) AAC competencies, such as the operational skills of generating messages, the strategic skills of when to generate them, and the repair skills when a mistake is made.

AAC modelling simultaneously addresses both opportunity and access barriers so long as the AAC system we model is visually and motorically accessible to the student. Students with severe disabilities and CCN frequently have co-occurring motor, sensory, and sensory perception challenges. Many students will find it difficult to access desired messages on an AAC system. Some students cannot physically target and indicate graphic symbols on a display. They need an alternative access method, such as switch scanning, eye gaze, head pointing, or partner-assisted scanning. Many students with severe disabilities struggle to visually process all of the symbols on the display, due to difficulties perceiving contrast and the differences between symbols. These students may need symbols that are color-saturated and visually distinct. Many students struggle with visual complexity, the ability to perceive a single symbol across a visually busy display. These students may need fewer symbols on each page of their display. Some students will benefit from partner-assisted scanning, where communication partners speak aloud and/or point to the symbols in a consistent order, while inviting the student to respond when they hear their selection. Partner-assisted scanning helps build an auditory map of the location of messages, so that message location becomes automatic and is less taxing on working memory. Over time, all these students will need carefully designed AAC vocabularies to ensure access to a wide range of messages.

AAC modelling can begin immediately with any student who cannot rely on speech to meet their communication needs, even before they have had an individual AAC assessment. Some school systems make a range of simple AAC technologies available to all classrooms, for any student who may benefit from graphic symbol support. Project Core offers a range of free, downloadable universal graphic symbol displays (http://www.project-core.com/communication-systems). Project Core includes a simple Universal Core Selection Tool (http://www.project-core.com/communication-systems) that can help teams match their students with symbol displays designed to meet a variety of visual and motor needs, including alternative access and 3D tactual symbols. These free symbol displays ensure that classroom teams can begin modelling an accessible symbol modality without delay while waiting for an individual AAC assessment. Individual AAC assessments can then occur after students have experienced the instructional opportunity to learn how symbols work to represent words and express meaning. Dynamic assessment during AAC modelling will generate data about the student's AAC needs that can be used when evaluating the student for their long-term, robust, individualized AAC solution. Regardless when they occur, AAC assessments should recommend a system that offers sufficient symbols for students to learn to distinguish between individual symbols, and to learn to use and combine symbols for a range of messages and purposes across multiple partners. Any student who fails to make progress with expressive symbolic language, despite access to AAC and AAC modelling across their school day, should be assessed for additional unmet access needs.

AAC modelling can also remove access barriers caused by receptive language challenges. Speech is both rapid-paced and fleeting, creating barriers to receptive language comprehension for students with auditory processing and language processing barriers. AAC modelling slows the communication partner's rate of speech. It prompts communication partners to share more concise messages and restrict their vocabulary to the most high-frequency words. Indicating symbols as we speak provides the student with a consistent visual referent for key words, supporting receptive language for students who struggle with comprehension. Some students benefit when AAC modelling occurs on high-tech devices with voice output, because the digitized speech is more consistent and has less inflection than spoken language.

AAC modelling develops symbolic language skills and visual symbol recognition (Biggs et al., 2018). Students learn to combine and recombine symbols to meet a variety of communication needs. Students with CCN who have no access to AAC systems or AAC modelling may perceive themselves as people who do not participate in the world of language. AAC modelling supports these students to develop their self-identity as communicators who can comment, complain, ask questions, and share ideas with others.

Shared reading. Shared reading is the interaction that occurs between an adult and student while they read text aloud (Ezell & Justice, 2005). Read-alouds provide access to texts that are beyond the student's current reading level. During shared reading, the reading partner invites the student to engage with both their partner and the text itself. Reading partners draw students' attention to print while demonstrating how we can speak aloud and discuss the words printed on a page. During shared reading, adults demonstrate why we use texts and how we handle the tools of reading, whether that tool is a book, a magazine, a website, a personal letter, or a shopping list. The goal of shared reading is to foster knowledge of books and a love of reading while students learn to participate in and direct the reading experience.

Students with severe disabilities face multiple opportunity barriers to participate in shared reading. Young children with severe disabilities are read to less often than their nondisabled peers (Marvin, 1994). Some of this is simply lack of time. Many families spent the early years focused on addressing medical and personal care needs, leaving less time for play and reading. Attitudinal barriers may also play a part, particularly if the child did not respond to speech or did not appear interested in books. In the absence of comments from the child, parents and other reading partners may simply read text aloud from front-to-back, with limited interactions with what can be pointed to on the page. This knowledge and skill barrier can be addressed by teaching reading partners how to foster interaction and follow the student's lead.

Many students face access barriers to engaging in shared reading. Children with severe disabilities may demonstrate less apparent interest in text-based activities. Receptive language difficulty or sensory processing challenges may make it difficult to engage in joint attention or even just to sit still. Children with visual or auditory processing challenges may turn away from books. Without AAC, children with CCN lack access to a means of commenting, requesting, or directing the actions of their reading partner. Motor disabilities may prevent children from touching the page to show their interest or drawing the attention of their reading partner to something on the page. The result is that many students with severe disabilities are passive participants in the reading experience.

The intervention of shared reading requires the partner to read the text in an engaging manner, drawing the student's attention to what can be pointed to on each page. The reading partner models AAC, demonstrating a possible comment. AAC modelling with each page of the book invites the student to participate in the reading process. The reading partner provides adequate wait time so that the student can consider a possible message and organize their body to respond.

Shared reading addresses both access and opportunity barriers. Daily shared reading builds experience with reading so that the routine becomes familiar and predictable to the student. The time committed to this routine begins to compensate for missed opportunities to read with others earlier in childhood. Adults physically handle the books, removing motor barriers. Educators support attention by focusing on interaction rather than simply finishing the read-aloud. Page-by-page interactions with text and visuals foster attention and support working memory. The emphasis on engagement reminds educators to identify the characteristics that are most appealing to that particular student, such as a joyful tone of voice, simple bold visuals, or a slower reading pace. Multiple readings of the same text fosters self-identity as a reader, when students begin to memorize repeated phrases and predict what is coming next. AAC modelling combined with shared reading demonstrates how the student can participate in the reading process itself.

Independent reading. Independent reading gives children access to texts so they can explore them on their own, practicing the reading behaviors they have observed. Students physically handle the reading materials and directly manipulate the pages. These interactions with reading materials are the student's opportunity to independently apply what they are learning about print while developing the dispositions required for lifelong reading (Owocki & Goodman, 2002). All students need to experience independent reading, long before they are able to read or understand printed words.

Students with severe disabilities face multiple access barriers to independent reading. Many do not have the motor skills to independently explore traditional books or even move over to where books are available. Sensory processing challenges may cause the child to fixate on the physical properties of the book so that they just crinkle or rip the pages. Vision impairment or challenges with visual processing may limit access to printed text and images. Students with CCN may struggle to indicate their interest in text and their choice in reading material. These access barriers contribute to opportunity barriers, where adults may restrict access to books to prevent property damage. Adults may interpret the student's access barriers as lack of interest or readiness for reading.

Students with severe disabilities need access to a large collection of interesting, age- and ability-appropriate reading materials. Many students require digital texts that can be manipulated with switch access or simple swiping motions on a touch screen. Students can follow along in their own version of a text while a reading partner or computer program reads the text aloud. Many students enjoy exploring wordless picture books, simple personal experience stories, text written by peers, environmental print like cereal boxes, captioned photo albums, and even videos with closed captions.

Shared writing. Shared writing instruction occurs almost incidentally when a typically developing young child draws a picture, then speaks the idea behind it to an adult who writes it down. The child generates the idea and the adult demonstrates how to represent that idea in print. The adult provides the scaffold for the child to imagine herself as a writer, as the adult supports her to capture and share her ideas with others. The shared writing process demonstrates the tools of writing while engaging students in co-creating the text itself. Shared writing experiences create the motivation for students to learn to generate text independently.

Students with severe disabilities and CCN face multiple access barriers to participate in ordinary early writing experiences. Without oral language, these students may have never generated symbolic language or seen their own idea represented as print. Sensory or language processing challenges may have affected how they attend to spoken language. Visual impairments may have restricted their ability to observe other people writing. Motor challenges may have meant that their attempts at scribble were never recognized as expressing an idea.

Shared writing as an intervention attempts to replicate these ordinary early writing experiences for students with severe disabilities and CCN. Students are scaffolded to generate text even before they know what writing looks like, how to produce it, or the purpose it serves (Erickson & Koppenhaver, 2020). Predictable charts are one of the most common and systematic methods to demonstrate writing tools and engage students as participants in the writing process. The adult selects an open-ended sentence frame or stem that is complete once the student provides the key idea that gives the sentence meaning. The sentence stem helps students stay on topic and reduces the cognitive and language demands of generating a complete sentence. The sentence stem is repeated with multiple students, combining repetition of the key words with the variety of individual responses. The resulting text is inherently engaging because it represents the students' own ideas and interests.

For example, the adult might select the sentence frame "I like to…" Students are encouraged to reflect on their favorite activities to finish their own sentence. Each student's name is written at the end of their sentence. The resulting chart might look like:

- I like to golf. (Mr. Johnson)
- I like to swim. (Ahmed)
- I like to play basketball. (Aleasha)
- I like to shop. (Malakai)

As the chart is created, students see their idea represented in print and hear the text spoken aloud. In follow-up activities, they re-read the print and explore conventions of print such as word order and punctuation. Teachers reference the print, noticing features such as word length and initial letters. These kinds of shared writing experiences provide students with severe disabilities an authentic way to create and participate in print beyond the level they can produce independently.

Independent writing. Young children engage in independent writing whenever they scribble with crayons, bang on a keyboard, text a string of messages from a parent's phone, or carefully compose a page of indecipherable shapes and explain that it is a letter to Nana. Independent writing is the process of exploring the tools of writing, problem-solving how to express meaning, and sharing ideas with an audience, even before the student can generate anything that is decipherable as a word.

Students with severe disabilities face multiple access barriers to participate in ordinary writing exploration. Motor impairment may make it impossible to grasp and coordinate the use of a traditional pencil or writing tool. Sensory defensiveness may prevent the child from grasping tools, while difficulties with range of motion or finger isolation can make a keyboard inaccessible. Vision challenges may make it difficult for the child to notice environmental print, observe models of writing, or distinguish individual letters. These access barriers can exacerbate opportunity barriers when students are perceived as random or destructive with traditional markers and paper. Knowledge barriers may result in educators focusing on the motor tasks of handwriting and tracing, rather than the cognitive work of generating ideas and sharing them in print. Assistive technology is usually necessary to provide students with a means of exploring and selecting letters. This technology can include keyboards, letter boards, alphabet flipcharts, label makers, magnetic letters, and much more. Students might access these technologies directly or with alternate access, such as switch scanning, eye gaze, or partner-assisted scanning.

Independent writing instruction models the writing process, then invites students to write their own ideas. This model of the writing process includes thinking of a purpose for writing, considering the audience, and selecting the individual letters. Educators start this instruction whenever they narrate "think-alouds" as they consider what to write and which letters to select. They maintain it when they provide students with accessible tools to select letters and set a topic along with daily opportunities to write. Educators complete the instruction when they celebrate the student's writing, provide specific feedback, and encourage the student to write even more. Whenever possible, the student's writing is published and shared, so that family, friends and others can celebrate the writing as well.

Independent writing is often paired with AAC, photos, remnants, or other cues about context. These support the student to indicate their topic for writing, the same way that a speaking child might say "I wrote a letter to Nana!" before sharing the letter itself. During independent writing, the student might select a photo of themselves swimming, then generate a string of letters. The photo sets the topic, so the adult has context to provide a response. The adult might comment, "I love what you wrote about swimming! I see lots of S's. I like to swim too! Can you write more about swimming?" This kind of feedback sustains motivation and confidence as students continue the hard work of learning to write.

Alphabet and phonological awareness. Knowledge of the alphabet is the foundation of conventional reading and writing. Students first develop awareness of the alphabet: the idea that letters exist, letters have names, each letter has its own unique form, letters are different from numbers or shapes, and letters are associated with specific sounds. This awareness evolves into the alphabetic principle: the understanding that the letters of the alphabet form a stable and predictable symbol set that represents the sounds of spoken language. Alphabet knowledge includes the ability to name and recognize letters (in both uppercase and lowercase), produce the form of each letter, and identify the sounds that letters represent. Reading and spelling are built on a student's ability to apply their knowledge of the alphabet and letter patterns.

Phonological awareness refers to a student's ability to distinguish and manipulate the sounds of spoken language. Students with strong phonological awareness can identify how many words are in a sentence or how many syllables are in a word. They notice that cat sounds like *hat* but different from *can* or *cot*. They can manipulate these sounds to create a rhyme with *mat*. They notice the alliteration of the *cat is crammed in the can*.

Students with severe disabilities and CCN struggle to develop phonological awareness (Dessemontet et al., 2017). Their access barriers include a lack of speech with which to babble and experiment with language. These students may be slow to develop an internal voice with which they can manipulate and explore language. Knowledge of the alphabet may also be slow to develop. Vision impairments may make it difficult to distinguish letters. Motor impairments may reduce their ability to handle and explore ordinary alphabet materials. Opportunity barriers, however, are likely the biggest barrier these students face in developing alphabet knowledge and phonological awareness. Special education programs have traditionally focused on rote letter identification without integrating that instruction into activities that demonstrate how students can apply that knowledge to reading and spelling (Browder et al., 2006). As a result, many students with severe disabilities demonstrate strong letter recognition but have not learned how letters are associated with the words we speak, spell, and read. Alphabet knowledge is associated with stronger future reading skills in students with severe disabilities educated in regular classrooms, where alphabet instruction is just one component of comprehensive literacy instruction rather than an isolated instructional task (Dessemontet & de Chambrier, 2015).

Students with severe disabilities and CCN need some explicit instruction in the alphabet and phonological awareness that teaches them to use their inner voice to name letters and manipulate the associated sounds. Like children without disabilities, they are likely to learn the letters of their own name before they learn other letters. Learning personally important letters helps students discover that they can learn letters, which in turn develops their curiosity in the rest of the alphabet. They benefit from instruction that is meaningful and relevant, such as creating and reading personalized alphabet books that associate letters with things the student knows and cares about. The student's AAC can be incorporated in phonological awareness instruction, as individual words are sequenced and re-ordered to form a variety of sentences. Students who cannot speak letter sounds may still be able to clap, nod, or rock their bodies to indicate they hear the beat of music and the syllables in words. Alphabet and phonological awareness instruction is easily embedded in shared reading, such as when we read books with rhyming text. We also provide this instruction during shared writing when we draw the student's attention to letters and words, notice features of different words, cut apart sentences into individual words, and explore word order when reconstructing sentences.

Conclusion

Students with severe disabilities come to school with a variety of access barriers to learning literacy and language skills. As educators, we have no control over the type and volume of access needs of the students in our classrooms. We do, however, have control over how we problem-solve solutions to these barriers and maximize opportunities to access literacy instruction. Careful attention to a student's access barriers helps us ensure that we have provided the assistive technologies and other accommodations that the student requires.

Comprehensive emergent literacy instruction removes the barriers to ordinary early childhood experiences of language and literacy. These routines are explicit and intentional at recreating the ordinary literacy opportunities that students with severe disabilities have often missed. They come together to provide comprehensive literacy instruction, removing barriers to language development and literacy.

The specific interventions that combine to form comprehensive emergent literacy instruction are generally familiar to early childhood educators. But they may be unfamiliar to educators of older students, particularly those at the secondary level. The list of interventions may appear daunting to these educators. Many interpret this list of interventions as a call to implement six new interventions, each with many steps of their own. The need for those interventions may then be used as a reason to remove a student from general classroom settings. However, each of these routines can be integrated into the day-to-day routines in regular classrooms. Samuel's team demonstrates that it is possible to incorporate the instruction he needs without excluding him or limiting learning opportunities with his peers. Teams do not have to choose between quality comprehensive emergent literacy instruction and inclusive education. Part 2 of this article presents an instructional framework developed to meet the needs of educators in inclusive classrooms.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author(s) of this paper.

References

Allor, J., Mathes, P., Roberts, J., Jones, F., & Champlin, T. (2010). Teaching students with moderate intellectual disabilities to read: An experimental examination of a comprehensive reading intervention. *Education and Training in Autism and Developmental Disabilities, 45*, 3-22.

Americans With Disabilities Act of 1990, Pub. L. No. 101-336, 104 Stat. 328 (1990).

Bailey, R., Angell, M., & Stoner, J. (2011). Improving literacy skills in students with complex communication needs who use augmentative/alternative communication systems. *Education and Training in Autism and Developmental Disabilities, 46*, 352-368.

Beukelman, D., & Mirenda, P. (2012). *Augmentative and alternative communication: Supporting children and adults with complex communication needs* (4th ed.). Baltimore, MD: Brookes.

Biggs, E., Carter, E., Bumble, J., Barnes, K., & Mazur, E. (2018). Enhancing peer network interventions for students with complex communication needs. *Exceptional Children, 85*, 66-85. doi:10.1177/0014402918792899

Biggs, E., Carter, E., & Gilson, C. (2018). A scoping review of the involvement of children's communication partners in aided augmentative and alternative communication modeling interventions. *American Journal of Speech-Language Pathology, 28*, 1-16. doi: 10.1044/2018_AJSLP-18-0024

Brock, M. (2018). Trends in the educational placement of students with intellectual disability in the United States over the past 40 years. *American Journal on Intellectual and Develop-mental Disabilities, 123*, 305-314. doi:10.1352/1944-7558-123.4.305

Brock, M., & Schaefer, J. (2015). Location matters: Geographic location and educational placement of students with developmental disabilities. *Research and Practice for Persons with Severe Disabilities, 40*, 154-164. doi:10.1177/1540796915591988

Browder, D., Courtade-Little, G., Wakeman, S., & Rickelman, R. (2006). From sight words to emergent literacy. In D. Browder & F. Spooner (Eds.), *Teaching reading, math, and science to students with significant cognitive disabilities* (pp. 63-91). Baltimore: Brookes.

Browder, D., & Spooner, F. (2006). *Teaching language arts, math and science to students with significant cognitive disabilities.* Baltimore, MD: Brookes.

Browder, D., & Spooner, F. (2011). *Teaching students with moderate and severe disabilities.* New York: The Guilford Press.

Browder, D., Spooner, F., Wakeman, S., Trela, K., & Baker, J. (2006). Aligning instruction with academic content standards: Finding the link. *Research and Practice for Persons with Severe Disabilities, 31*, 309-321. doi:10.1177/154079690603100404

Browder, D., Trela, K., Courtade, G., Jimenez, B., Knight, V., & Flowers, C. (2012). Teaching mathematics and science standards to students with moderate and severe developmental disabilities. *The Journal of Special Education, 46*(1), 26-35. doi:10.1177/0022466910369942

Browder, D., Wakeman, S., Spooner, F., Ahlgrim-Delzell, L., & Algozzinexya, B. (2006). Research on reading instruction for individuals with significant cognitive disabilities. *Exceptional Children, 72*, 392-408. doi:10.1177/001440290607200401

Buckley, S., Bird, G., Sacks, B., & Archer, A. (2006). A comparison of mainstream and special education for teenagers with Down syndrome: Implications for parents and teachers. *Down Syndrome Research and Practice, 9*, 54-67. doi:10.3104/reports.295

Bui, X., Quirk, C., Almazan, S., & Valenti, M. (2010). *Inclusive education research & practice.* Elkridge, MD: Maryland Coalition for Inclusive Education.

Calculator, S. (2009). Augmentative and alternative communication (AAC) and inclusive education for students with the most severe disabilities. *International Journal of Inclusive Education, 13*(1), 93-113. doi: 10.1080/13603110701284656

Carter, E. (2018). Supporting the social lives of secondary students with severe disabilities: Critical elements for effective intervention. *Journal of Emotional and Behavioral Disorders, 26*, 52-61. doi:10.1177/1063426617739253

Carter, E., Austin, D., & Trainor, A. (2012). Predictors of postschool employment outcomes for young adults with severe disabilities. *Journal of Disability Policy Studies, 23*, 50-63. doi:10.1177/1044207311414680

Carter, E., & Hughes, C. (2006). Including high school students with severe disabilities in general education classes: Perspectives of general and special educators, paraprofessionals, and administrators. *Research and Practice for Persons with Severe Disabilities, 31*(2), 174-185. doi: 10.1177/154079690603100209

Channell, M., Loveall, S., & Conners, F. (2013). Strengths and weaknesses in reading skills of youth with intellectual disabilities. *Research in Developmental Disabilities, 34*(2), 776-787. doi:10.1016/j.ridd.2012.10.010

Chung, Y., Carter, E., & Sisco, L. (2012). A systematic review of interventions to increase peer interactions for students with complex communication challenges. *Research and Practice for Persons with Severe Disabilities, 37*, 271-287. doi:10.1352/1944-7558-117.5.349

Copeland, S., & Cosbey, J. (2009). Making progress in the general curriculum: Rethinking effective instructional practices. *Research and Practice for Persons with Severe Disabilities, 33-4*(4-1), 214-227. doi:10.2511/rpsd.33.4.214

Cosier, M., Causton-Theoharis, J., & Theoharis, G. (2013). Does access matter? Time in general education and achievement for students with disabilities. *Remedial and Special Education, 34*(6), 323-332. doi:10.1177/0741932513485448

Dessemontet, R. S., Bless, G., & Morin, D. (2012). Effects of inclusion on the academic achievement and adaptive behaviour of children with intellectual disabilities. *Journal of Intellectual Disability Research, 56*, 579-587. doi:10.1111/j.1365-2788.2011.01497.x

Dessemontet, R., & de Chambrier, A. (2015). The role of phonological awareness and letter–sound knowledge in the reading development of children with intellectual disabilities. *Research in Developmental Disabilities, 41-42*, 1-12. doi:10.1016/j.ridd.2015.04.001

Dessemontet, R. S., de Chambrier, A. F., Martinet, C., Moser, U., & Bayer, N. (2017). Exploring phonological awareness skills in children with intellectual disability. *American Journal on Intellectual and Developmental Disabilities, 122*, 476-491. doi:10.1352/1944-7558-122.6.476

Durando, J. (2008). A survey on literacy instruction for students with multiple disabilities. *Journal of Visual Impairment and Blindness, 102*, 40-45. doi:10.1177/0145482X0810200105

Dymond, S., Renzaglia, A., Rosenstein, A., Chun, E., Banks, R., Niswander, V., & Gilson, C. (2006). Using a participatory action research approach to create a universally designed inclusive high school science course: A case study. *Research and Practice for Persons with Severe Disabilities, 31*(4), 293-308. doi:10.1177/154079690603100403

Endrew F., a Minor, by and Through His Parents and Next Friends, Joseph F. et al. v. Douglas County School District RE–1, 64 IDELR 38, (D., Co. 2014), 580 U.S. ____ (2017).

Erickson, K. (2017). Comprehensive literacy instruction, interprofessional collaborative practice, and students with severe disabilities. *American Journal of Speech-Language Pathology, 26*, 193-205. doi: 10.1044/2017_AJSLP-15-0067

Erickson, K., & Geist, L. (2016). The profiles of students with significant cognitive disabilities and complex communication needs. *Augmentative and Alternative Communication, 32*, 187-197. doi:10.1080/07434618.2016.1213312

Erickson, K., Hanser, G., Hatch, P., & Sanders, E. (2009). *Research-based practices for creating access to the general curriculum in reading and literacy for students with significant intellectual disabilities* (pp. 1-175). Chapel Hill: Center for Literacy and Disability Studies, University of North Carolina. Retrieved from https://www.med.unc.edu/ahs/clds/files/2019/01/Reading-and-Literacy-for-Students-with-Significant-Intellectual-DisabilitiesErickson-et-al-2009-1.pdf

Erickson, K., & Koppenhaver, D. (2020). *Comprehensive literacy for all: Teaching children with significant disabilities to read and write.* Baltimore, MD: Brookes.

Ezell, H. K., & Justice, L. M. (2005). *Shared storybook reading: Building young children's language and emergent literacy skills.* Baltimore, MD: Paul H. Brookes Publishing Co.

Feldman, R., Carter, E., Asmus, J., & Brock, M. (2016). Presence, proximity, and peer interactions of adolescents with severe disabilities in general education classrooms. *Exceptional Children, 82*, 192-208. doi: 10.1177/0014402915585481

Fisher, D., & Frey, N. (2001). Access to the core curriculum: Critical ingredients for student success. *Remedial and Special Education, 22*(1), 148-157. doi: 10.1177/074193250102200303

Fisher, M., & Meyer, L. (2002). Development and social competence after two years for students enrolled in inclusive and self-contained educational programs. *Research and Practice for Persons with Severe Disabilities, 27*, 165-174.

Ganz, J., Rispoli, M., Mason, R., & Hong, E. (2014). Moderation of effects of AAC based on setting and types of aided AAC on outcome variables: An aggregate study of single-case research with individuals with ASD. *Developmental Neurorehabilitation, 17*(3), 184-192. doi:10.3109/17518423.2012.748097

Hanser, G., & Erickson, K. (2007). Integrated word identification and communication instruction for students with complex communication needs: Preliminary results. *Focus on Autism and Other Developmental Disabilities, 22*, 268-278. doi:10.1177/10883576070220040901

Hart, B. & Risley, T. (1999). *The Social World of Children: Learning to Talk.* Baltimore, MD; Brookes.

Hunt, P., McDonnell, J., & Crockett, M. (2012). Reconciling an ecological curricular framework focusing on quality of life outcomes with the development and instruction of standards-based academic goals. *Research and Practice for Persons with Severe Disabilities, 37*, 139-152. doi:10.2511/027494812804153471

Individuals with Disabilities Education Act Amendments, Assistance to States for the Education of Children with Disabilities and Preschool Grants for Children With Disabilities, 71 Fed. Reg. 156, 34 CFR §300 and §301 (2006).

Jackson, L., Ryndak, D., & Wehmeyer, M. (2008). The dynamic relationship between context, curriculum and student learning: A case for inclusive education as a research-based practice. *Research and Practice for Persons with Severe Disabilities, 33-4*(4-1), 175-195. doi:/10.2511/rpsd.33.4.175

Jimenez, B., Browder, D., & Courtade, G. (2008). Teaching an algebraic equation to students with moderate developmental disabilities. *Education and Training in Developmental Disabilities, 43*, 266-274.

Jimenez, B., Browder, D., Spooner, F., & Dibiase, W. (2012). Inclusive inquiry science using peer-mediated embedded instruction for students with moderate intellectual disability. *Exceptional*

Children, 78, 301-317. doi:10.1177/001440291207800303

Joseph, L., & Seery, M. (2004). Where is the phonics? A review of the literature on the use of phonetic analysis with students with mental retardation. *Remedial and Special Education, 25*, 88-94. doi:10.1177/07419325040250020301

Kamps, D., Royer, J., Dugan, E., Kravits, T., Gonzalez-Lopez, A., Garcia, J., …Kane, L. (2002). Peer training to facilitate social interaction for elementary students with autism and their peers. *Exceptional Children, 68*(2), 173-187. doi:10.1177/001440290206800202

Katims, D. (2000). Literacy instruction for people with mental retardation: Historical highlights and contemporary analysis. *Education & Training in Mental Retardation & Developmental Disabilities, 35*(1), 3-15.

Kearns, J., Kleinert, H., & Erickson, K. (2019). Strategies for supporting AAC use in inclusive general education classrooms. *Impact, Institute on Community Integration, 31*(2), 32-33.

Kearns, J., Towles-Reeves, E., Kleinert, H., Kleinert, J., & Thomas, M. (2011). Characteristics of and implications for students participating in alternate assessments based on alternate academic achievement standards. *Journal of Special Education, 45*(1), 3-14. doi: 10.1177/0022466909344223

Kleinert, H., Browder, D., Towles-Reeves, E. (2009). Models of cognition for students with significant cognitive disabilities: Implications for assessment. *Review of Educational Research, 79*(1), 301-326. doi: 10.3102/0034654308326160

Kleinert, H., Towles-Reeves, E., Quenemoen, R., Thurlow, M., Fluegge, L., Weseman, L., & Kerbel, A. (2015). Where students with the most significant cognitive disabilities are taught: Implications for general curriculum access. *Exceptional Children, 81*, 312-328. doi:10.1177/0014402914563697

Kliewer, C. (2008). Joining the literacy flow: Fostering symbol and written language learning in young children with significant developmental disabilities through the four currents of literacy. *Research and Practice for Persons with Severe Disability, 33*(3), 103-121. doi: 10.2511/rpsd.33.3.103

Koppenhaver, D., Coleman, P., Kalman, S., & Yoder, D. (1991). The implications of emergent literacy research for children with developmental disabilities. *American Journal of Speech Language Pathology, 1*, 38-44. doi: 10.1044/1058-0360.0101.38

Koppenhaver, D., & Yoder, D. (1993). Classroom literacy instruction for children with severe speech and physical impairments (SSPI): What is and what might be. *Topics in Language Disorders, 13*(2), 1-15. doi:10.1097/00011363-199302000-00003

Kurth, J., & Mastergeorge, A. (2012). Impact of setting and instructional context for adolescents with autism. *The Journal of Special Education, 46*(1), 36-48. doi:10.1177/0022466910366480

Lee, S., Wehmeyer, M., Soukup, J., & Palmer, S. (2010). Impact of curriculum modifications on access to the general education curriculum for students with disabilities. *Exceptional Children, 76*, 213-233. doi: 10.1177/001440291007600205

Light, J. (1989). Toward a definition of communicative competence for individuals using augmentative and alternative communication systems. *Augmentative and Alternative Communication, 5*, 137-144.

Marvin, C. (1994). Home literacy experiences of preschool children with single and multiple disabilities. *Topics in Early Childhood Special Education, 14*, 436-454. doi:10.1177/027112149401400405

Meyer, L. (2001). The impact of inclusion on children's lives: Multiple outcomes, and friendship in particular. *International Journal of Disability, Development and Education, 48*(1), 9-31. doi: 10.1080/10349120120036288

McDonnell, J., Thorson, N., & McQuivey, C. (2000). Comparison of the instructional contexts of students with severe disabilities and their peers in general education classes. *Journal of the Association for Persons with Severe Handicaps, 25*, 54-58. doi: 10.2511/rpsd.25.1.54

Mims, P., Lee, A., Browder, D., & Zakas, T., & Flynn, S. (2012). Effects of a Treatment Package to Facilitate English/Language Arts Learning for Middle School Students with Moderate to Severe Disabilities. *Education and Training in Autism and Developmental Disabilities*, *47*, 414-425.

Owocki, G. & Goodman, Y. (2002). *Kidwatching: Documenting children's literacy development.* Portsmouth, NH: Heinemann.

Pressley, M., & Allington, R. (2014). *Reading instruction that works: The case for balanced teaching* (4th ed.). New York, NY: Guilford Press.

Quirk, C., Ryndak, D., & Taub, D. (2017). Research and evidence-based practices to promote membership and learning in general education for students with extensive support needs. *Inclusion, 5*(2), 94-109. doi:10.1352/2326-6988-5.2.94

Ruppar, A., Dymond, S., & Gaffney, J. (2011). Teachers' perspectives on literacy instruction for students with severe disabilities who use augmentative and alternative communication. *Research and Practice for Persons with Severe Disabilities, 36*(3-4), 100-111.

Ruppar, A., Fisher, K., Olson, A., & Orlando, A. (2018). Exposure to literacy for students eligible for the alternate assessment. *Education and Training in Autism and Developmental Disabilities, 53*, 192-208.

Ruppar, A., Gaffney, J., & Dymond, S. (2015). Influences on teachers' decisions about literacy for secondary students with severe disabilities. *Exceptional Children, 81*, 209-226. doi:10.1177/0014402914551739

Ryndak, D., Jackson, L., & White, J. (2013). Involvement and progress in the general curriculum for students with extensive support needs: K–12 inclusive-education research and implications for the future. *Inclusion, 1*(1), 28-49. doi:10.1352/2326-6988-1.1.028

Ryndak, D., Hughes, C., Alper, S., & Mcdonnell, J. (2012). Documenting impact of educational contexts on long-term outcomes for students with significant disabilities. *Education and Training in Autism and Developmental Disabilities, 47*, 127-138.

Ryndak, D., Moore, M., & Delano, M. (2009). Access to the general curriculum: The mandate and role of context in research-based practice for students with extensive support needs. *Research and Practice for Persons with Severe Disabilities, 34*(1), 199-213. doi:10.2511/rpsd.33.4.199

Ryndak, D., Morrison, A., & Sommerstein, L. (1999). Literacy prior to and after inclusion in general education settings. *Journal of The Association for Persons with Severe Handicaps, 24*, 5-22. doi: 10.2511/rpsd.24.1.5

Ryndak, D., Ward, T., Alper, S., Montgomery, J., & Storch, J. (2010). Long-term outcomes of services for two persons with significant disabilities with differing educational experiences: A qualitative consideration of the impact of education experiences. *Education and Training in Autism and Development Disabilities, 45*, 323-338.

Sauer, J., & Jorgensen, C. (2016). Still caught in the continuum: A critical analysis of least restrictive environment and its effect on placement of students with intellectual disability. *Inclusion, 4*(2), 56-74. doi:10.1352/2326-6988-4.2.56

Soukup, J., Wehmeyer, M., Bashinski, S., & Bovaird, J. (2007). Classroom variables and access to the general curriculum for students with disabilities. *Exceptional Children, 74*, 101-120. doi:10.1177/001440290707400106

Towles-Reeves, E., Kearns, J., Kleinert, H., & Kleinert, J. (2009). An analysis of the learning characteristics of students taking alternate assessments based on alternate achievement standards. *Journal of Special Education, 42*, 241-254. doi:10.1177/0022466907313451

Wagner, M., Newman, L., Cameto, R., & Levine, P. (2006). The academic achievement and functional performance of youth with disabilities. *A Report from the National Longitudinal Transition Study-2* (NLTS2). NCSER 2006-3000. Online Submission. Retrieved from https://files.eric.ed.gov/fulltext/ED494936.pdf

White, E. (1952). *Charlotte's web*. New York, NY: Harper & Row.

Wehmeyer, M., & Palmer, S. (2003). Adult outcomes for students with cognitive disabilities three years after high school: The impact of self-determination*. Education and Training in Developmental Disabilities, 38*, 131-144.

Witzel, B., & Allsopp, D. (2007). Dynamic concrete instruction in an inclusive classroom. *Mathematics Teaching in the Middle School, 13*, 244-248.