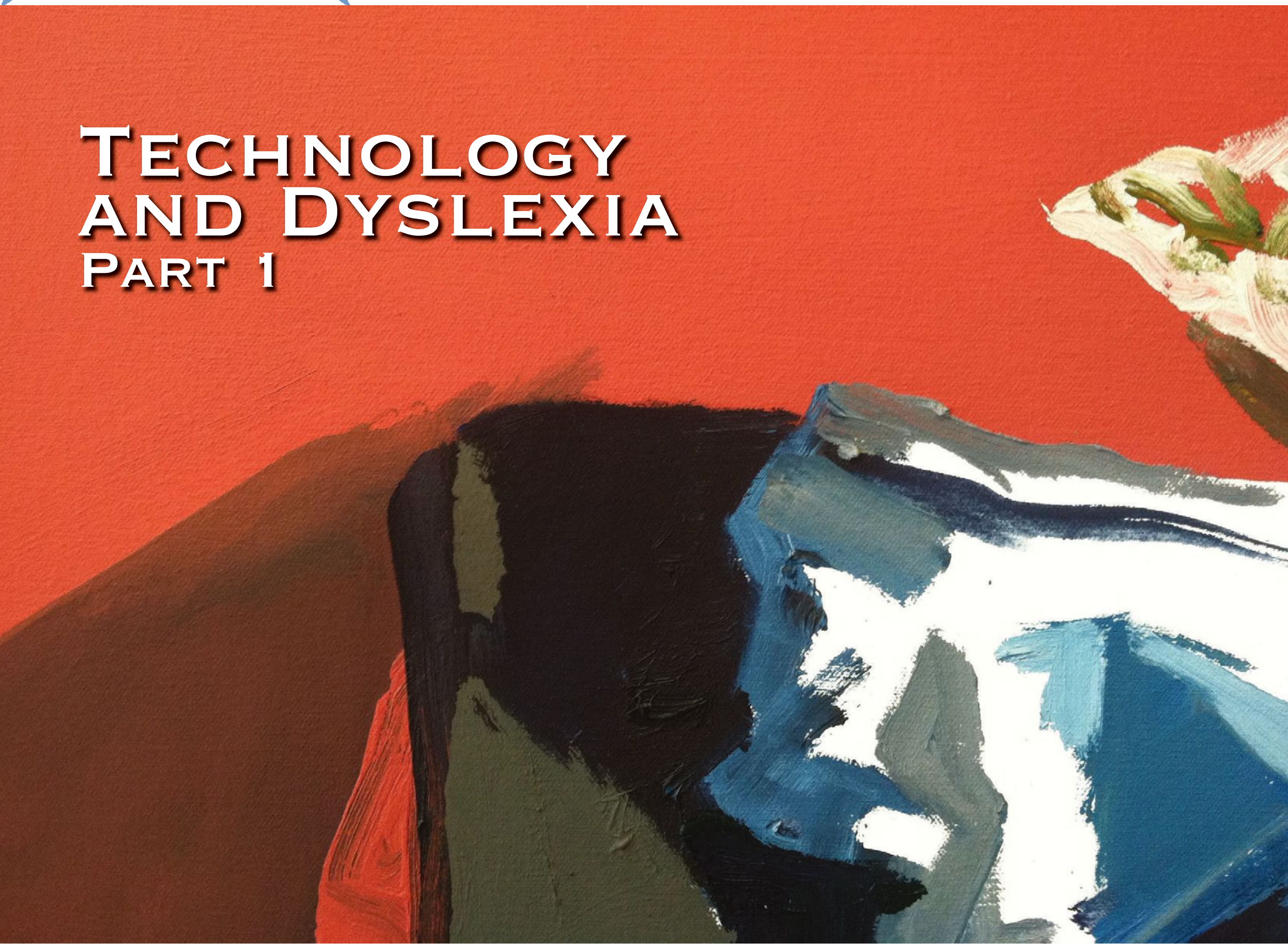
Fall Edition 2013

Perspectives on Language and Literacy

A Quarterly Publication of The International Dyslexia Association

Volume 39, No. 4

Technology and Dyslexia Part 1



The International DYSLEXIA Association®

Promoting literacy through research, education, and advocacy.™

FALL EDITION 2013

PERSPECTIVES

ON LANGUAGE AND LITERACY

A Quarterly Publication of The International Dyslexia Association *Volume 39, No. 4*

IDA PURPOSE STATEMENT

The purpose of IDA is to pursue and provide the most comprehensive range of information and services that address the full scope of dyslexia and related difficulties in learning to read and write…

In a way that creates hope, possibility, and partnership…

So that every individual has the opportunity to lead a productive and fulfilling life, and society benefits from the resource that is liberated.

The International Dyslexia Association (IDA) is a 501(c)(3) non-profit, scientific and educational organization dedicated exclusively to the study and treatment of the specific language disability known as dyslexia. We have been serving individuals with dyslexia, their families, and professionals in the field for over 55 years. IDA was first established to continue the pioneering work of Samuel T. Orton, M.D., in the study and treatment of dyslexia.

IDA's membership is comprised of people with dyslexia and their families, educators, diagnosticians, physicians, and other professionals in the field. The headquarters office in Baltimore, Maryland is a clearinghouse of valuable information and provides information and referral services to thousands of people every year. IDA's Annual Conference attracts thousands of outstanding researchers, clinicians, parents, teachers, psychologists, educational therapists, and people with dyslexia.

TECHNOLOGY AND DYSLEXIA—PART 1

ON THE COVER: Detail of "Crumpled," a painting by Sam Allerton Green, an Artist in Residence at the Creative Alliance in Baltimore, Maryland. Sam received his BFA from the Maryland Institute College of Art in 2010. To see more of his work, visit http://www.samallertongreen.com/

IDA supports efforts to provide individuals with dyslexia with appropriate instruction and to identify these individuals at an early age.

While IDA is pleased to present a forum for presentations, advertising, and exhibiting to benefit those with dyslexia and related learning disabilities, it is not IDA's policy to recommend or endorse any specific program, product, speaker, exhibitor, institution, company, or instructional material, noting that there are a number of such which present the critical components of instruction as defined by IDA.

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Please direct them to Kristen Penczek or Denise Douce at info@interdys.org

The opinions of the authors are not necessarily the opinions of the International Dyslexia Association.

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From the President's Desk

This year in New Orleans, as in years past, IDA has brought to our conference local, national, and world-renowned presenters who are lecturing on the latest research and evidence-based practices in education and allied disciplines. The conference also provides an excellent opportunity to honor those in the field who have helped advance the science and practice of reading instruction as it relates to dyslexia, as well as exceptional teachers and individuals with dyslexia who are an inspiration to us all.

This year's Samuel T. Orton Award, IDA's highest honor, is conferred on **Louisa Moats, Ed.D.**, a researcher, writer, author, and consultant specializing in language, reading, and spelling development. Louisa is also a wonderful friend. While serving on IDA's national board she was the chair of the committee that developed IDA's *Knowledge and Practice Standards for Teachers of Reading*.

Alice Thomas is the first recipient of the Presidential Award of Excellence, which is conferred on an individual who has made a significant contribution in the field of dyslexia and reading instruction while working in the vicinity of the host city for the conference. Alice is the founder, president, and CEO of the nonprofit Center for Development and Learning (CDL) in Metairie, Louisiana. She is also an author of books for parents and teachers and the creator and director of the annual evidence-based *Plain Talk about Reading Institute*.

Our 2013 Pinnacle Award recipient is **Blake Charlton, M.D.**, a successful novelist and medical resident who is dyslexic. The Pinnacle Award was created to recognize a individual with dyslexia who has publicly acknowledged such, made significant achievements in his or her field of interest, is leading a successful life, and is a role model for others with dyslexia. Dr. Carlton has published two fantasy novels—*Spellwright* and *Spellbound*—that feature a dyslexic hero living in a world in which anything written down can be peeled off of a page and made physically real. His books have been translated into eight languages. Dr. Carlton is a resident at the University of California in San Francisco.

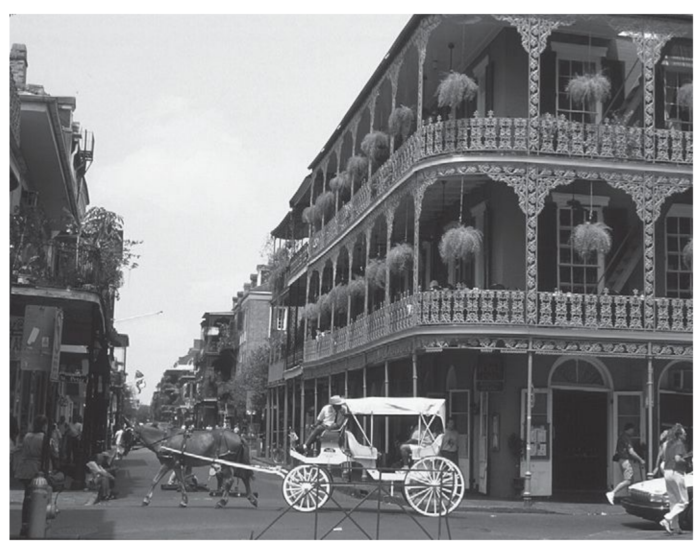
This year's recipient of the Margaret Rawson Award is **Diana King, Lit.hum. Dr.h.c., F/AOGPE**. She is the founder of the Kildonan School and a dedicated teacher to those who struggle with dyslexia. Born in the United Kingdom, Diana began her career in the United States at Sidwell Friends Academy in Washington, DC. She then founded the Dunnerback, a camp for children with learning difficulties, and, in 1980, she established the Kildonan School in Amenia, New York.

We are also fortunate to have **Laurie E. Cutting, Ph.D.,** deliver the Norman Geschwind Memorial Lecture on Friday, November 8, 2013. Dr. Cutting is the Patricia and Rodes Hart Associate Professor of Special Education, Associate Professor of Psychology, Radiology, and Pediatrics, and Faculty Director at the Vanderbilt Kennedy Center Reading Clinic. She will present some of her work on the neurobiology of dyslexia and recent findings that have shed light on some of the brain mechanisms of reading comprehension.

We have four wonderful **preconference seminars** this year on assistive technology, ADHD, and executive function, neuroscience research in dyslexia, and promotion of vocabulary growth. In addition, IDA is holding our **2nd Annual Conference for Families**. **Laura Cassidy, M.D.,** the President of Louisiana Key Academy and **Congressman Bill Cassidy, M.D.,** the Co-Chair of the Congressional Dyslexia Caucus, will be the keynote speakers on Saturday, November 9, 2013. We also partnered with **Decoding Dyslexia** to lead **Parent Roundtables** on the afternoon of Friday, November 8. The conference's closing event will be hosted by another IDA partner, **Learning Ally**, on Saturday, November 9, at 7:00 p.m. with their **National Big Picture Roadshow**, a presentation of the documentary *The Big Picture: Rethinking Dyslexia*.

I hope that you have the opportunity to enjoy the 64th IDA National Conference and the unique and exciting culture of New Orleans. Laissez les bons temps rouler!

Eric Tridas, M.D.
President



The Samuel T. Orton Award

Congratulations to **Louisa Moats, Ed.D.**, *President of Moats Associates Consulting, Inc.; Author of* LETRS professional development program *and* Speech to Print: Language Essentials for Teachers, recipient of the 2013 Samuel T. Orton Award.

The Samuel T. Orton Award, IDA's highest honor, was established in 1966. This award recognizes a person or persons, who have made a vital contribution to our scientific understanding of dyslexia, significantly enhanced and advanced our capacity to successfully intervene and assist people with dyslexia, expanded national and international awareness of dyslexia, or demonstrated unusual competence and dedication in service to people with dyslexia.

The Margaret Byrd Rawson Lifetime Achievement Award

Congratulations to **Diana Hanbury King, Lit.hum. Dr.h.c., F/AOGPE**, *Founder, The Kildonan School,* recipient of the 2013 Margaret Byrd Rawson Award.

The Margaret Byrd Rawson Lifetime Achievement Award recognizes the work of an individual in advancing the mission of the International Dyslexia Association. The award is given to an individual whose work on behalf of IDA embodies Margaret Rawson's compassion, leadership, commitment to excellence, and fervent advocacy for people with dyslexia.

The Pinnacle Award

Congratulations to **Blake Charlton, M.D.**, *Novelist and Medical Resident, r*ecipient of the 2013 Pinnacle Award.

The Pinnacle Award was created to recognize an individual with dyslexia who has publicly acknowledged such, has made significant achievements in his or her field of interest, is leading a successful life, and is a role model for others with dyslexia. The award is given annually, more than one person may receive this recognition in any given year; and the honoree does not have to be a member of IDA.

The Remy Johnston Certificate of Merit Award

Congratulations to **Thomas Hircock**, recipient of the 2013 Remy Johnston Certificate of Merit Award.

The Remy Johnston Certificate of Merit was established to honor the memory of a fine student with dyslexia whose promising life was tragically cut short a few months prior to graduating from college. The Certificate of Merit recognizes a young student with dyslexia who is a worthy role model for others, refuses to be limited by the challenges of learning differences, strives for excellence, chooses to live as an achiever, and continues to enrich the lives of families, friends, employers, and the communities in which he or she lives through service.

The IDA Presidential Award of Excellence

Congratulations to **Alice Thomas**, Founder & CEO of the Center for Development & Learning, recipient of the IDA Presidential Award of Excellence.

IDA created this award in 2013 to honor an individual who, through their profession, tirelessly aims to improve the lives of those with dysleixa. This award is given in recognition of excellence in service to individuals with dyslexia, their families, and the greater community.

Theme Editors' Introduction

Technology and Dyslexia—Part 1

by David H. Rose, Sam Catherine Johnston, and Amy E. Vanden Boogart

This is the first of two special issues on technology in education for *Perspectives on Language and Literacy*. Together, the two issues will cover a fairly broad landscape where dyslexia and technology intersect. But it is a landscape that is very difficult to capture at this particular moment in time—beneath its surface are dynamic and disruptive forces that are rapidly reshaping its fundamental "geology."

A brief history of the present two-volume collection reflects those dynamic forces at work. In the beginning, IDA proposed one special issue of *Perspectives* and asked us to serve as editors. After several months of discussion among the three of us, along with colleagues in the field, it became clear that this rich and expanding landscape of material was too much for one issue. When they became aware of the breadth and depth of the landscape to address, IDA graciously extended our geography—we could encompass the complete contents of two issues rather than one. That is the first sign of the underlying dynamics—a rapidly expanding landscape to cover.

But there is a second seismic shift evident in recognizing the boundaries *of* the two issues. Our original conception was for two issues that were quite distinct in the themes they addressed. The first issue would focus on Assistive Technology (AT). In that issue, we would present articles that centered on the individual *student*—examining the power of new technologies to assist individuals with dyslexia in overcoming barriers in their environment. The second issue was to focus instead on the learning *environment*—examining the power of new technologies to reduce barriers in the learning environment for students with dyslexia from the outset (what is often called Universal Design for Learning, UDL).

As we began to receive articles for the first issue it became clear that this distinction—once fairly clear-cut—was no longer sharply divided. This blurring of the line between AT and UDL reflects an underlying shift in the implementation of technology within this field: the contours that once separated AT and UDL are dynamically changing. Many technologies that were formerly implemented as AT have now been incorporated into UDL implementations. UDL approaches to education now more routinely incorporate and integrate the advances of AT. In the articles presented in these two issues the complementary nature of UDL and AT—previously articulated *in principle* (e.g., Rose, Hasselbring, & Zabala)—are now being implemented *in reality*. As a result, the separation between our first and second issues is significantly less clear: the landscapes that once seemed very separate are increasingly merging in practice (a good thing!).

There is a third seismic shift evident in these two issues. At the outset, the concept for these issues implicitly assumed that their actual publication would adopt the printed format of *Perspectives*. Over the last several years, however, the explosive forces of digital publishing, e-books, web-books, user-centered design, and many other evolving technologies too numerous to list, have so changed the landscape that the printed format no longer seems foundational or adequate, but merely habitual—one option among many. Moreover, the nature of the articles we are gathering cry out for a more flexible set of options than print would allow. As a result, for the first time we are publishing some of the articles not only in print, but also in multiple enhanced UDL versions. UDL allows us to demonstrate, rather than merely describe, the fundamental changes in the learning landscape as it is increasingly experienced by dyslexic learners.

With the changing geology behind us, we would like to re-introduce the content of the first issue. Although its content will inevitably interweave with the content of the second issue, for the reasons described above, this issue will emphasize the AT contributions to the new landscape. For the reader unfamiliar with some of the terms that will recur throughout these issues, we would like to provide some background.

What is Assistive Technology?

Zabala (2010) describes AT as devices and services that enhance abilities and reduce barriers to achievement. She emphasizes that AT decisions need to be related to the function AT helps an individual to perform rather than to a specific disability, and, that its use extends across disability groups, across settings, and across time (Zabala, 2010). Temple and DeCoste in their articles in this issue underscore the importance of AT for learners with disabilities in classroom settings. Temple indicates that AT is used by a student with a disability to complete a learning task independently and at an expected performance level. Importantly, without AT, the student would be unable to perform the task independently or proficiently. Both authors reference the Individuals with Disabilities Education Act (IDEA) requirement that districts ensure AT is provided when needed and that consideration of AT be part of each Individualized Education Program (IEP) planning process.

What is Universal Design for Learning?

UDL derives in part from the concept of *universal design* in architecture, where the goal is to engineer products, buildings, or environments so that they are accessible for the widest possible range of users, regardless of age or abilities. Virtually all architects in the U.S. now create public buildings that are designed from the outset to reduce or eliminate architectural barriers by considering the needs of diverse people. This practice is now recognized as significantly more cost-effective and equitable than trying to retrofit buildings later or providing customized accommodations to individuals who are unable to navigate poorly designed structures. While originally conceived to meet the needs of individuals with disabilities,

Continued on page 8

universal designs actually make buildings that are more useful and functional for everyone. UDL is one part of the overall movement toward universal design that focuses on the special demands and purposes of learning environments. As such, the framework and guidelines for UDL are not derived from the principles for architecture. Instead, they are based on research and practice from multiple domains within the learning sciences—education, developmental psychology, cognitive science, and cognitive neuroscience. The research in those fields guides both the scope of the pedagogy that UDL addresses (i.e., the critical elements of teaching and learning) and the range of the individuals that UDL addresses (i.e., the critical elements of individual differences). At its simplest, the scope of UDL is based entirely on three principles:

1. Provide Multiple Means of Representation
2. Provide Multiple Means of Action and Expression
3. Provide Multiple Means of Engagement

The National Center on UDL *(www.udlcenter.org)* offers further information on these three principles.

How do UDL and AT relate in the changing landscape of education?

Consider an analogy from medicine, the treatment of black lung disease. Two very different kinds of treatments are important. The first recognizes the disease as a medical condition afflicting the individual—immediate and sustained individual medical treatment is required. The second recognizes the disease as a public health problem—it has been inordinately prevalent, even epidemic, among coal miners. To reduce the incidence of black lung disease requires not only the treatment of afflicted *miners*, but also the treatment of afflicted *mines*. To treat black lung disease adequately, both approaches are essential: corrective measures that focus on the health of individual miners and corrective measures that focus on the health and toxicity of the environment. Failing to address both parts of the equation will ensure that more and more miners are debilitated.

Traditionally, the use of AT for students with dyslexia has been comparable to primary medicine: practitioners focus on the needs of individual learners and fashion a customized intervention with specialized tools and techniques. In traditional classrooms where printed materials, such textbooks, dominate instruction, students with dyslexia have *print disabilities* (a new term) and need specialized treatment and tools to ameliorate their disabilities. AT serves to provide the tools and techniques that teachers and students can use to bridge the gap between the ways in which these students learn effectively, and the limited media, materials, methods, and assessments chosen as the curriculum.

As digital technology becomes common in classrooms, its use enriches the media, materials, methods, and assessments that constitute the curriculum, providing many options that were unavailable previously. In digital classrooms, especially those that adopt principles of UDL in their teaching, there are fewer barriers to learning for any student, including those with dyslexia. In these new environments AT complements UDL in the same way that individual medicine complements public health (and vice versa): there are enabling tools and "good medicine" for individuals, and there is also less toxicity in the environment, wider opportunities for success, and better "air" to breathe for everyone.

Introducing the First Issue

With all of this as background, we wish now to introduce the content of the first issue. The authors in this issue, all pre-eminent in the field of AT, were asked to focus on the contemporary role and significance of AT for students with dyslexia. It is a sign of the dynamic changes in the field, however, that each of them went beyond our initial charge to illustrate the complementary roles of AT and UDL in an overall technology approach to dyslexia.

Within that landscape, there are several different themes that run though these articles. We would like to highlight several of those themes as a way of introducing the individual articles. (Readers already familiar with the field of AT will note the strong, and intentional, parallel with Joy Zabala's SETT framework (Zabala, 2005) for the implementation of AT, to which we are indebted.)

First, individuals matter. In her article on reading and AT ("Reading and Assistive Technology: Why the Reader's Profile Matters"), Erickson describes research with elementary and middle school students who have reading difficulties to illustrate how learner variability (in addition to the requirements of the learning tasks) needs to be carefully examined before deciding on AT. The study examined the strengths and weaknesses of each of the students in the sub-skills of reading (i.e., word identification, listening comprehension, and silent reading comprehension) and found that Text to Speech (TTS) for accessing electronic text was helpful for students with specific profiles of strengths and weaknesses in these sub-skills when they were presented with certain reading tasks. In other cases, where students had a different profile of strengths and weaknesses, TTS actually interfered with the reading task. Erickson's article reminds us of the larger issue: to optimize the impact of AT will require paying close attention to the student, and especially to the individual differences among students.

Temple ("Executive Function Skills and Assistive Technology") buttresses that same point by focusing on one particularly under-attended characteristic of many students with dyslexia—difficulties with executive function. Many reading programs treat students with dyslexia as a relatively homogeneous group, focusing on the same rudimentary, entry-level skills, such as phonics or building fluency, for all of the students. Temple's article instead focuses on the role of technology in addressing some of the specific higher-order skills of reading that are actually fundamental for adolescent readers. For some students with dyslexia, the programs and apps she recommends to support executive functioning will be an essential element of their arsenal moving forward. Not to attend to the individual differences in what students need, especially among those with dyslexia, is to miss the individualizing power of AT.

Second, environments matter. DeCoste's article ("The Changing Roles of Assistive Technology Teams in Public School Settings") describes how one public school district has moved from a model of providing AT to single users through a referral process administered by an expert, to a capacity-building approach for the whole district. This capacity-building approach still meets the needs of individual students, but focuses on building the capacity of the school and system to use AT to meet the needs of a broad range of students. The district DeCoste profiles uses two primary frameworks to support collaborative decision-making around AT, the SETT framework (Zabala, 2010) and the Universal Design for Learning framework (Meyer, Rose & Gordon, 2013). Importantly, this combined approach leads to broader adoption of AT and less stigma for the students using AT. DeCoste's article captures the evolutionary role of AT (i.e., encompassing both medical treatment and public health approaches) within the context of a single, large school district—without a supportive environment, the power of AT is radically diminished.

Third, tasks matter. Two articles emphasize the importance of carefully attending to the content-specific demands of different domains and different levels of learning when making AT choices. Okolo and Kopke ("Disciplinary Literacy and Technology for Students with Learning Disabilities") specifically illustrate how important it is to consider the difference between different domains of inquiry or learning. They illustrate how AT use should differ in science and history teaching. The former is focused on discovery and hypothesis testing to understand core principles that explain nature; whereas, the latter is interpretive and designed to understand the roles of different stakeholders and factors that contribute to a set of circumstances over time. The authors show how different disciplines require different orientations to learning (and literacy), and, therefore, they also often require not only different AT, but also different approaches to using the same AT.

Similarly, Edyburn's article ("Assistive Technology and Writing") illustrates how important it is to recognize the different levels of instruction that emerge within a single domain. Within the domain of writing, he shows that AT can, and must, be used differentially to support a wide range of skills that extend from the physical act of putting pen to paper (e.g., TTS, keyboarding), all the way to the metacognitive processes of turning one's thinking into something that others can see. In this article, Edyburn focuses on three "higher level" processes that are especially challenging for learners with learning disabilities, namely, learning to engage in writing regularly, planning to write, and preparing a first draft. In his article he provides research and associated web 2.0 tools to help educators think about AT choices for these metacognitive writing tasks, while also making the key point that careful attention to the goals and demands of the intended task matters.

Fourth, technology matters. By definition, AT depends upon the use of modern technologies. Optimizing AT requires recognizing the relative affordances of new and emerging technologies in the marketplace and matching them with specific students, environments, and tasks. Winters and Cheesman ("Mobile Instructional and Assistive Technology for Literacy"), in particular, discuss the affordances of newer mobile technologies (in particular, the iPad and iPhone) for both instructional technology and AT. These new affordances change the landscape of learning significantly in many ways: anytime-anywhere use, capacity to sync data, AT within a single device (i.e., no external keyboard), and continually evolving apps that can be updated easily. While extolling the virtues of mobile, the authors call for criteria for evaluating mobile apps including content validated by research, presence of appropriate scaffolds and timely feedback, professional sound and images, and intuitive and user-friendly interfaces. Every author in this issue advances one or more strategies for vetting AT, which is critical given the volume of products that exist, the pace with which they change, and the democratization of the decision-making process around AT to support learning.

As all of these articles show, the new media and technology landscape of which AT is a part will surface new opportunities in classroom learning for students with dyslexia. A richer approach to materials, media, methods, and assessments broadens what literacy means and what skills it demands of learners. Yet, as these articles also show, optimizing the power of new technologies will also require educators, researchers, and technology specialists to carefully consider what new barriers may arise for students with dyslexia as they navigate this richer environment. We hope that this special issue, and the one to follow, will contribute some of the knowledge teachers and students need to successfully navigate this new landscape.

Reference

Zabala, J. (2005, February/March). Ready, SETT, Go: Getting started with the SETT framework. *Closing the Gap, 23*(6), 1–3.

***David H. Rose, Ed.D.**, is a developmental neuropsychologist and educator whose primary focus is on the development of new technologies for learning. In 1984, Dr. Rose co-founded CAST, a not-for-profit research and development organization whose mission is to improve education, for all learners, through innovative uses of modern multimedia technology and contemporary research in the cognitive neurosciences. That work has grown into the field called Universal Design for Learning which now influences educational policy and practice throughout the United States and beyond. Dr. Rose also teaches at Harvard's Graduate School of Education where he has been on the faculty for almost 30 years.*

Dr. Rose is the co-author of several scholarly books, numerous award-winning educational technologies, and dozens of chapters and research journal articles. He has been the principal investigator on large grants from the National Science Foundation, the U.S. Department of Education, and many national foundations. In the policy arena, he was one of the authors of the recent National Educational Technology Plan, has testified before the U.S. Senate, and helped to lead the development of the National Instructional Materials Accessibility Standard. Dr. Rose has won many awards,

Continued on page 10

including recently being honored at the White House as a "Champion of Change." Dr. Rose holds a B.A. in psychology from Harvard College, a master's in teaching from Reed College, and a doctorate from the Harvard Graduate School of Education.

***Sam Catherine Johnston, Ed.D.**, is a research scientist at CAST with expertise in peer-based learning models, distance and blended education and program evaluation. Her primary research focus has been on the use of technology-mediated peer-based learning to transfer knowledge and foster behavior change among interdisciplinary groups of professionals and para-professionals working in various fields including mental health care, education, criminal justice, and human services. At CAST Dr. Johnston directs a Bill and Melinda Gates Funded project to improve the capacity of community colleges to develop high quality Open Educational Resources (OERs) that utilize the principles of Universal Design for Learning to ensure all learners can benefit from OERs. Dr. Johnston also works as a researcher on a national center that examines the experiences of K–12 students with disabilities in online and blended learning courses and programs. Before joining CAST, Dr. Johnston was a Senior Associate and Distance Educator at the Center for Social Innovation (c4si), leading the company's online learning strategy.*

***Amy E. Vanden Boogart, M.Ed.**, is the Curriculum Specialist for Community Academy Public Charter Schools, where she manages the alignment of the curriculum of four elementary schools to the Common Core State Standards. Her primary responsibilities are the rollout of the curriculum and the ongoing training of teachers, coaches, and principals on effective curriculum implementation and literacy instruction. Amy has also worked as a reading and language arts curriculum designer and assessment writer, and she is a former elementary teacher. In addition, she is an adjunct professor teaching a course on children's reading development for the Special Education and Disability Studies department at George Washington University. Amy is a doctoral candidate in Curriculum & Instruction at George Washington University, where her research interests include upper elementary teacher knowledge for and beliefs about teaching reading, professional development for reading teachers, and how iPads and other emerging technologies can benefit reading instruction.*

Reading and Assistive Technology: Why the Reader's Profile Matters

by Karen Erickson

Assistive technology (AT) can take many forms; however, as a support for reading, electronic text is a core feature of AT. Anderson-Inman and Horney offer a typology that describes the types of resources that can be used to vary the supportiveness of electronic text (Anderson-Inman & Horney, 1998; Horney & Anderson-Inman, 1999). The typology focuses on the function that each of the resources plays in the supported reading process (e.g., translational, explanatory, and illustrative) and is intended to serve as a conceptual framework that guides the selection of appropriate AT for students who struggle with reading. Table 1 shows a recent version of this typology as presented by Anderson-Inman and Horney (2007).

While the typography does fairly represent the range of supports that are possible given today's technologies, there is little research to guide its use with students with dyslexia. In general, research supporting the use of AT in reading for students with dyslexia is limited, and research to guide the selection of specific supports to meet individual student needs is even more limited. Yet, understanding the possible impact of AT on the reading skills of students with dyslexia requires that we move beyond questions regarding the use of AT generally or electronic texts specifically and focus on the impact that AT supports have on students with varying profiles of strength and weakness in reading.

AT, Reading, and Dyslexia

It is well understood that dyslexia is a specific learning disability that is neurological in origin and characterized by difficulties with accurate and fluent word recognition and decoding abilities. AT, specifically text-to-speech with electronic text, has long been recognized as an important reading

Continued on page 12

TABLE 1. Abbreviated Version of Anderson-Inman and Horney's (2007) Typology of Resources for Supported Etext[1]

Resource	Description
Presentational	Allows for variations in the presentation of text and graphics including changes to font size and style, text and background color, line and page length, page layout and graphics layout
Navigational	Supports movement within and between documents via links, embedded menus, and links from other resources such as Table of Contents, Glossary, Bibliography
Translational	Provides one-to-one translation of words, phrases, paragraphs, graphics, or the entire document via synonyms, definitions, text-to-speech, alternate language equivalents (Spanish), reduction of reading level, text descriptions for images, captions for video
Explanatory	Clarifies the what, where, how, or why of concepts, objects, processes, or events via descriptions that point to causes, operations, components, mechanisms, parts, methods, procedures, context, or consequences; may also provide lists of influencing factor(s)
Illustrative	Provides visual representations and examples via drawings, photos, simulations, video, sounds, music, and other forms of information that something is representative of its type ("...is a typical example of...")
Summarizing	Provides a summarized or shortened view of some aspect of the document via a table of contents, concept map, list of key ideas, chronology, timeline, cast of characters, abstract
Enrichment	Offers supplementary information such as background information, publication history, biography of the author, footnotes, bibliography, influence on other writers
Instructional	Teaches some aspect of the text with instructional prompts, questions, strategies, tutorials, annotations, study guides, online mentoring, tips for effective reading
Notational	Supports note taking and marking up the text via electronic highlighting, bookmarking, margin notes, outlining, drawing along with a means of gathering and grouping notes for post-reading review
Collaborative	Supports working with or sharing with others via threaded discussion, online chat, e-mail links, podcasts, blogs
Evaluational	Provides a means of assessing student learning via questions, quizzes, tests, surveys, online interviews, assignments leading to products

Note. Adapted from "Supported eText: Assistive Technology through Text Transformations," by L. Anderson-Inman and M. A. Horney, 2007, *Reading Research Quarterly*, *42*(1), p. 154.

[1] An etext (from "electronic text") is, generally, any text-based information that is available in a digitally encoded, human-readable format and read by electronic means

solution for students with dyslexia (see, e.g., Abelson & Petersen, 1983; Anderson-Inman et al., 1990), and as technology has become ubiquitous, text-to-speech solutions are becoming commonplace. However, research regarding the use of AT to support reading for students with dyslexia has not kept pace with the development of the technology itself (Holmes & Silvestri, 2012).

Extant research supports text-to-speech solutions as a means of improving reading rates and comprehension for students with dyslexia (Elkind, 1993) and learning disabilities more broadly (Elkind, 1998; Montali & Lewandowski, 1996). For students with learning disabilities, text-to-speech has a positive impact on vocabulary (Elkind, Cohen, & Murray, 1993), phonological decoding and word recognition (Olson & Wise, 1992), and silent word reading and oral reading of text (Elbro, Rasmussen, & Spelling, 1996), and importantly, these skills transfer to improved reading skills with printed materials (Elkind, Cohen, & Murray, 1993). However, the impact of text-to-speech on reading rate and comprehension is not uniform. In a study of adults with severe reading disabilities, the impact of text-to-speech was greatest for individuals with the poorest silent reading skills (Elkind, Black, & Murray, 1996).

Higgins and Raskind (1997) investigated the supportiveness of text-to-speech for postsecondary students with learning disabilities. They found that the intervention led to gains in reading comprehension overall, but a more careful examination of the findings revealed that, like Elkind, Black, and Murray (1996), gains were greatest for students with the poorest silent reading ability without AT, and text-to-speech actually interfered with the reading comprehension of students with the best silent reading skills. This type of profile-based approach to understanding which students benefit from text-to-speech and other AT is important. Unfortunately, most of the research regarding AT to date fails to consider subtypes of learning disabilities (Holmes & Silvestri, 2012) and profiles of strengths and weaknesses in reading.

A Closer Look

Reading difficulties in students with dyslexia are often explained with respect to the Simple View of Reading (Gough & Tunmer, 1986), which suggests that reading ability can be explained by the combination of one's ability to identify written words and comprehend language (i.e., listening comprehension). Students with dyslexia, by definition, struggle with word identification, especially the phonological decoding aspects of word identification, and are believed to struggle with comprehension of text as a result of these difficulties in word identification. However, deficits in word identification often exist in the absence of difficulties comprehending text through listening. Furthermore, the difficulties students with dyslexia experience with reading comprehension may be influenced by deficits in other aspects of reading that extend beyond those reflected in the Simple View. Finally, profiles of relative strengths and weaknesses in reading are not static, especially if students are engaged in effective reading interventions that systematically target areas of need. As a result, the decisions we make about the use of AT to support reading should not be static.

Understanding the impact that AT can have on the reading success of students with dyslexia requires that we take a closer look at the profile of strengths and weaknesses presented by individual students and monitor that profile over time. It also requires that we consider their abilities in silent reading and listening comprehension in the absence of AT relative to the difficulty of the text they are being asked to read. If the text exceeds not only the student's silent reading ability but also the student's listening comprehension ability, text-to-speech will offer little support. Furthermore, until we start investigating Anderson-Inman and Horney's typology of resources (Anderson-Inman & Horney, 1998; Horney & Anderson-Inman, 1999) that vary the supportiveness of electronic text relative to these profiles of strength and weaknesses and abilities in silent reading and listening comprehension, we will not move forward in our understanding of how best to use AT to support reading for students with dyslexia.

A group of 51 students (36 were male) in grades 3–8 in one school system offers a concrete example of this point. The students were involved in a reading intervention program guided by an individually administered diagnostic reading inventory. The inventory identifies a student's profile of strengths and weaknesses and abilities in word identification, listening comprehension, and silent reading comprehension per the Whole-to-Part (WTP) model of silent reading comprehension (Cunningham, 1993). The 51 students all qualified for special education services because of a learning disability and the results of the individually administered diagnostic reading inventory suggests that they have difficulties with accurate and/or fluent word recognition and decoding abilities. They are the subgroup of students participating in the reading intervention program who have a profile of abilities consistent with dyslexia, and they help demonstrate why we must be more precise in considering profiles of individual students when making decisions about AT and when recruiting and describing participants in research. Before considering how their individual profiles and abilities can influence the impact of AT on reading, it is important to understand more about the WTP model.

The Whole-to-Part Model

The WTP Model of silent reading comprehension (Cunningham, 1993) begins with the assertion that reading comprehension requires word identification, language comprehension, and whole text print processing (i.e., silent reading fluency). Each of these integrated abilities is part of silent reading comprehension ability, yet each can be considered an independent whole that also is composed of its own parts. A diagnostic reading inventory based on the WTP model assesses a student's ability to identify words, listen with comprehension, and read silently with comprehension without looking back at the text when responding to questions.

TABLE 2. Grade of Record for Participants

3rd grade	4th grade	5th grade	6th grade	7th grade	8th grade
7 (13.7%)	14 (27.5%)	8 (15.7%)	4 (7.8%)	11 (21.6%)	7 (13.7%)

TABLE 3. Race/Ethnicity for Participants

Black/African American	White	Hispanic	Multi-Racial	Asian/Pacific Islander
7 (13.7%)	29 (56.9%)	13 (25.5%)	1 (2.0%)	1 (2.0%)

Word identification is the cognitive process of making print-to-sound links to translate both familiar and unfamiliar printed words into pronunciations (Cunningham & Cunningham, 1978; Perfetti, Bell, & Delaney, 1988; Van Orden, Johnston, & Hale, 1988). For students with dyslexia, word identification vocally, subvocally, or neurologically, is the component of reading that is consistently impaired. In contrast, language comprehension, which involves knowledge of the world and processing of text structures, is not always impaired. Students with dyslexia often have deep knowledge of the world or background knowledge and experience related to the topics assumed by a text's author. Furthermore, they are often quite successful in accessing knowledge of text structures including syntax, cohesive ties, and organizational or genre patterns (Frank, Grossi, & Stanfield, 2006) to support comprehension through listening. In contrast, students with dyslexia often struggle with the final component of the WTP model, whole text print processing, because they have had limited successful experience with the silent reading practice that is required to build these skills. Specifically, whole text print processing is composed of at least five parts: 1) eye-movement strategies (see, e.g., Rayner & Pollatsek, 1989); 2) inner speech (see, e.g., Daneman & Newson, 1992; Slowiaczek & Clifton, 1980); 3) print-to-meaning links (see, e.g., Van Orden, 1991); (4) prosody projection (see, e.g., Cowie, Douglas-Cowie, & Wichmann, 2002); and 5) integration. Each of these parts can only be developed through successful silent reading practice. As such, students with dyslexia typically struggle with these parts of reading.

Why Profiles Matter

Data from the following study provides a good example of why learner profiles are so important. The 51 students who participated in the system's reading intervention each completed the individually administered diagnostic assessment to determine their profile relative to the WTP model. As such, each student's grade level equivalent in word identification, listening comprehension, and silent reading comprehension was assessed directly. To provide a more complete picture of the group of students, their grade of record and race/ethnicity is provided in Tables 2 and 3 respectively.

Table 4 offers a snapshot of the word identification, listening comprehension, and silent reading comprehension skills of these 51 students relative to their grade of record. These are precisely the students to whom we try to provide assistive technologies to support their reading, yet their reading profiles suggest that they require different types of technologies.

If we examine the whole group of 51 students, the relative weakness in word identification coupled with listening comprehension skills that are slightly above grade level would suggest that the group would benefit from text-to-speech access to grade-level text; however, there is great variation within the group that cannot be ignored. This variation may explain why the extant research regarding AT to support reading for this population is equivocal.

The WTP profiles of these 51 students help us understand that 33 can listen with comprehension at or above grade level and would likely benefit immediately from access to digitized text and text-to-speech. The remaining 18 students struggle to identify the words and also struggle to understand text when others read it to them. These 18 students listen with comprehension one or more grade levels below their grade of record. Certainly, text-to-speech would provide them with support in identifying the words, but it would do little to support their understanding of the text. Perhaps the addition of some of the

Continued on page 14

TABLE 4. Number of Years below Grade Level in the Components of the WTP

	Word Identification	Listening Comprehension	Silent Reading Comprehension
At or above grade level	2 (3.9%)	33 (64.7%)	21 (41.2%)
1 grade level below	8 (15.7%)	10 (19.6%)	10 (19.6%)
2 grade levels below	23 (45.1%)	6 (11.8%)	17 (33.4%)
3 or more grade levels below	18 (35.3%)	2 (4.0%)	3 (5.9%)
Mean (standard deviation)	2.29 (1.08)	-.1176* (1.72)	.8088 (1.21)

*note: the group listens with comprehension slightly above grade level.

support features highlighted in Anderson-Inman and Horney's typology could be added to allow these 18 students to comprehend more successfully. For example, *explanatory* resources might clarify the meaning or *instructional* resources might teach critical concepts. However, the resources that are highly supportive for those students who are only 1 year behind are unlikely to provide enough support for students who are 3 or more years behind grade level in their ability to listen with comprehension. These students may require resources that are *translational* and simplify the text or *illustrative* and offer visual or multimedia representations of the text.

Interestingly, 21 of the students (41.2%) read text silently with comprehension at a level that exceeds their ability to decode words in isolation. These students are likely using strong language comprehension and print processing skills to determine the meaning of text and decode individual words that they cannot decode out of context. This may be the type of reading profile exhibited by the participants in the two studies (Elkind, Black, & Murray, 1996; Higgins & Raskind, 1997) that found that text-to-speech was most beneficial for students who had the lowest silent reading skills. Looking at the profiles for the 21 students in this study, it is possible the text-to-speech interferes with the processes they are currently using to silently read and understand text without pronouncing each of the words.

Summary

Carefully considering a student's complete profile is not only beneficial at the level of the individual student, but it is imperative that research on the use of AT in reading report not just a disability label, global reading score, or word identification score for the participants in the study. We must stop asking, "Is AT effective?" and start asking, "Which students benefit from this AT?" and "Which combination of supports is best?" Responding to these questions requires that we more carefully describe the reading profiles of research participants.

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Executive Function Skills and Assistive Technology

by Cheryl Temple

Executive functioning is often referred to as the conductor, director, or controller of cognitive skills to manage tasks and succeed in goal-directed activities. Galinsky (2010) suggests that we should think about executive function as managing, not ordering: "We use [these skills] to manage our attention, our emotions, and our behavior in order to reach our goals" (p. 4). Dawson and Guare (2009) discuss two dimensions of executive skills: thinking and doing. *Thinking* skills help students select and achieve goals and solve problems using strategies such as prioritizing, planning, organizing, self-monitoring, and metacognition. *Doing* skills help students accomplish those tasks and involve skills such as response inhibition, emotional control, sustained attention, task initiation, persistence toward achieving a goal, and flexibility.

Executive Function and Academic Success

Most experts also agree that there is a direct correlation between executive function and academic success. Blair and Razza (2007) found that executive function is more strongly predictive of school readiness and academic success than intelligence quotients (IQ). As cited in Galinsky (2010), Adele Diamond of the University of British Columbia also indicates that evidence shows that executive function predicts success better than IQ tests. According to Meltzer (2010) students with weak executive function skills experience difficulty "in deploying and coordinating the many skills needed for such tasks as open-ended projects, term papers, and tests" (p. 4). Most academic tasks require students to coordinate and integrate many different skills. Weaknesses in executive function "can have a significant impact on the accuracy and efficiency of students' performance. Writing, summarizing, note taking and reading complex text for meaning may be particularly challenging" (Meltzer, 2010, p. 6).

Many different strategies can be used to promote the development of executive functioning. Galinsky (2010) offers suggestions on topics such as focus and self-control, perspective taking, communicating, making connections, critical thinking, taking on challenges, and self-directed learning. Cannon, Kenworthy, Alexander, Werner, and Anthony (2011) wrote an executive function curriculum, which is full of practical ideas and strategies, especially for children with autism spectrum disorders. Dawson and Guare (2010) expand interventions from individual students to include the whole class. Judy Willis, a neurologist who became a classroom teacher, suggests many related strategies to "ignite student learning" at her website *Radteach.com*.

Improving Executive Function Skills with Assistive Technology

The Individuals with Disabilities Education Act (IDEA) specifically requires every Individualized Education Program (IEP) team to consider the student's need for assistive technology at some point during the meeting. Furthermore, every school district is required to ensure that assistive technology devices and services are provided if needed. Assistive technologies, like any intervention, may be used in several different ways as part of an educational plan. Meltzer (2010), for example, argues that students with executive function weaknesses will benefit from 1) systematic and explicit instruction in executive function skills and 2) accommodations for classwork and homework. Specific applications—both low tech and high tech—that seem particularly helpful or promising in either of these ways are highlighted in this article. The suggestions that follow are organized by skill category: prioritizing, planning, organizing, self-monitoring, and working memory. This list is far from exhaustive, but it is meant to stimulate thinking of ways to use technology to support executive function skills.

Prioritizing

Students with executive function weaknesses are often described as "impulsive" or "distractible" because they seem to have difficulty maintaining longer-term goals and priorities. Unfinished projects and disorganized attempts lie in the wake of rapidly shifting interests and the inability to resist "attractive nuisances" in the environment that interfere with reaching longer-term priorities.

Many students, of course, face these difficulties in their hyper-connected, multimedia-rich world: a world in which they are continually distracted by email, Facebook, YouTube videos, and other social media tools. Fortunately "there are apps for that;" apps that might also benefit students with wider executive function difficulties by helping them establish, track, and achieve goals and priorities. Consider SelfControl. Aptly named, this app (currently available for Mac only) gives students more "self-control" by allowing them to set priorities for their attention pre-emptively, before they face attractive distractions. More specifically, SelfControl allows students to block access to websites, mail servers, and any other distractions on the Internet for the period of time determined by the student. Other similar apps include Habits Pro, an organizer for goals, tasks, and health tracking; Goal Tracker, an app for tracking daily tasks, chores, routines, or goals; Priority Matrix, a tool to help students manage their priorities; and ChoiceWorks, a picture-based tool to help students complete daily routines and make appropriate choices. A high tech option is use of an app such as iStudiezpro (discussed below), which can be used to prioritize homework and projects.

Low-tech options can also help with setting and maintaining priorities, for example, using colored folders to prioritize what needs to be done. A blue folder might contain items that need to be completed when feasible, a yellow folder might contain items for next week, and a red folder might mean that the items have to be completed as soon as possible. Marking papers with little arrow tabs or page markers in different colors might be another way of prioritizing.

Continued on page 16

Planning

Visual schedules allow students to see what is expected of them during the day and help with planning and transitioning. For example, the daily or weekly schedule is put in a plastic frame and an erasable marker is used to check off tasks as they are completed. If the tasks remain the same, the schedule can be wiped clean and the date updated each week. Pictures can be used for younger children still learning to read.

Apps are also available for keeping track of homework such as myHomework and iStudiezpro, which are effective for some students. With myHomework, an app that works on a wide variety of devices, students can track their classes, homework, tests, and assignments. iStudiezpro (available for Mac, iPhone, or iPad) allows students to have a daily and weekly view, track assignments and grades, access a schedule planner to help break down long-term assignments, and create an interactive calendar. Some students who are provided with a homework app on a mobile device, go from being totally dependent on an adult to write down their assignments, to totally independent using an app. Independence is often one of the benefits of using technology. There are many other apps for tracking homework, but the important thing is to consider what the student needs to be successful and look for those components in the app you choose.

Checklists can be an important way to remind students of tasks needed to be completed or to break down long-term assignments. Checklists can easily be created using most word processing tools. There are also many websites that allow the user to create their own checklist. One tool that allows the user to create a project checklist is the Online Checklist Creator at *http://pblchecklist.4teachers.org/checklist.shtml*

Organizing

A graphic organizer is a tool that supports students in organizing and remembering. Graphic organizers are a visual aid that helps students organize their thoughts or concepts into visual categories and make the relationships between those thoughts or concepts visually explicit. By doing so, graphic organizers help students identify areas of focus within a broad topic and to structure their thinking and make connections—all of which aid memory. Visit *www.inspiration.com* for free trial downloads of a graphic organizing program. Other organizers can be found at Teachnology *(www.teach-nology.com/web_tools/graphic_org/)* or Education World *(http://www.educationworld.com/tools_templates/index.shtml)*.

Other apps allow students to create graphic organizers on their mobile devices. Mobile Learning Services has an app called Tools4Students which has graphic organizers to help students with chapter notes, writing, comprehension skills, and blank organizers that can be customized. They can be saved to personal devices and emailed.

Self-Monitoring

It is often helpful for any student, but especially those with difficulties in self-monitoring, to explicitly chart their own progress and watch their academic growth. This practice helps them become active in evaluating their own progress. Self-monitoring especially comes into play as students recognize the need to make changes in their strategies or approach. Willis (2009) talks to her students about why different strategies enhance brain function and has students chart the relationship between the achievement of their goals and their level of effort. To help scaffold self-monitoring by making it more explicit, students can chart their own progress using a spreadsheet tool or with an online tool such as *Onlinecharttool.com*.

Rubrics are particularly valuable as an aid to self-monitoring because they help students understand clearly what is expected. Allowing students to self-assess using a rubric and then comparing the self-assessment to the teacher assessment may help students learn to recognize short- and long-term goal progress. Rubric generators can be found online:

http://rubistar.4teachers.org/index.php

http://www.teachervision.fen.com/teaching-methods-and-management/rubrics/4521.html

http://www.teach-nology.com/web_tools/rubrics/

Physical or online timers can also be used to help students with self-monitoring. These timers can be set to remind students of events or to regulate the amount of time they are allocating to complete a certain task. Online timers such as the following can be helpful to students:

Online Timer	*http://timer.onlineclock.net/*
Time Me	*http://www.timeme.com/timer.htm*
Time and Date	*http://www.timeanddate.com/timer/*

Timers are also available on many mobile devices and can be used to support self-monitoring.

Fortunately, there are hundreds of productivity apps available on the market today that are designed to help busy executives and parents alike in monitoring their own progress toward goals. Many of these tools are also valuable to help scaffold and support students with executive function difficulties. Often the apps that come with a mobile device such as the calendar, notes, camera, clock, and reminders can address self-monitoring, all without stigmatization from their peers.

Working Memory

Many "executive" tools overcome the limits of working memory. Taking notes—on lectures, written articles, instructions, etc.—is one of the most common strategies for "outsourcing" working memory demands to a more permanent medium. But note taking is an area of difficulty, particularly for students with dyslexia, because of the additional writing skills required. To support students with note-taking difficulties, many teachers provide copies of the notes or other students take notes and provide a copy. However, this makes the student dependent on someone else. Technology does offer some tools to increase the independence of these students. If the student has access to a mobile device, he or she can use apps such as AudioNote or Sound Note. These types of apps allow students to take minimal notes in writing while recording the audio directly for later reference. The audio is linked to the written notes for easy and direct retrieval. Another similar tool is the Smartpen by Livescribe *(www.livescribe.com)*. This pen-like device allows students to combine handwritten notes (and drawings) with audio recording. The newest model of the pen utilizes Wi-Fi and allows the student to link audio files to visual notes and then have them stored in the cloud (a network of servers that makes files and applications available over the Internet). Accessing notes from the cloud reduces the need to be constantly searching for the physical piece of paper because the notes can be accessed anytime.

Voice Recorders such as the Audio Memo app are another useful tool. They allow students to quickly record a message on an iPhone or iPad, which frees up space in their working memory. Other apps like Dragon Dictation also provide an easy way to record thoughts.

Auditory recording is not the only medium available to scaffold working memory. Many students also have a camera on their mobile phone or other devices—a great tool for capturing visual information. With a camera, students can take pictures of notes, assignments, ideas in the classroom, etc. Everything can be stored on the mobile device so the student does not have to remember the information or locate a stray piece of paper.

AT Resources

Check out the resources below for additional way to use AT, including more ways to develop or continue developing executive function skills.

The Center for Implementing Technology in Education *(http://www.cited.org/index.aspx)* identifies evidence-based practices for integrating instructional technology to support the achievement of all students. In addition, there is a Tech Matrix that guides the user in targeting searches to find the right assistive technology product.

Montgomery County High Incidence Accessible Technology *(http://www.montgomeryschoolsmd.org/departments/hiat/)* has many ideas for supporting teachers using technology to support all students.

Quality Indicators for Assistive Technology (QIAT) *(http://www.qiat.org)* contains many documents for guiding the selection, implementation, and evaluation of assistive technology.

Technology and Media (TAM) Division of CEC *(http://www.tamcec.org)* supports educational participation and improved results for individuals with disabilities and diverse learning needs through the selection, acquisition, and use of technology.

Wisconsin Assistive Technology Initiative (WATI) *(http://www.wati.org)* has many documents on assessing students' needs for assistive technology, which may be helpful for the selection and evaluation of tools to support executive function.

UDL Playground *(http://edu.symbaloo.com/mix/udlplayground20132)* contains short videos of various apps and programs that might be appropriate to support various executive function skills.

So Much Technology, How Do You Choose?

Executive function skills are so important for academic success and life in general. For students who are having difficulty with some areas of executive functioning, technology may help. Technology changes constantly, so finding quality tools to support executive function can be challenging and may require trial and error—but don't give up. Finding the right match is worth it in the end.

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The Changing Roles of Assistive Technology Teams in Public School Settings

by Denise C. DeCoste
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Assistive Technology (AT) dates back to the 1980s and has evolved as a result of technology product development and disability legislation (Blackhurst & Edyburn, 2000), such as the U.S. Technology-Related Assistance for Individuals with Disabilities Act of 1988, known as the Tech Act. The U.S. Individuals with Disabilities Education Act Reauthorization (IDEA) of 1997 established the requirement that AT devices and services be considered for all students receiving special education services. AT publications and conferences provided the knowledge base for AT providers. Also in the 1980s, the Closing the Gap Conference and the California State University–Northridge (CSUN) Technology and Persons With Disabilities Conference offered a wealth of AT information. Following those early developments, numerous books, journals, and other resources such as the Education Tech Points (Bowser & Reed, 1998, revised in 2012), the Student, Environment, Tasks, and Tools (SETT) framework (Zabala, 2005), and the Quality Indicators of Assistive Technology (Zabala et al., 2000) set the bar for high quality student-centered AT teams.

Most AT teams started with a focus on students with complex, low incidence disabilities, those most in need of technology to speak and participate academically (e.g., students with physical, sensory, or cognitive impairments). Over time, new software tools were designed to address the reading, writing, and organizational needs of students with high incidence disabilities (e.g., learning disabilities, language disabilities, high functioning autism spectrum disorders, and attention deficits). The development of mobile technologies (e.g., tablets and smartphones), and internet-based tools (e.g., Glogster, Animoto, VoiceThread, and Khan Academy) have created more mainstream technology tools that benefit all students. Web-based networking and online productivity tools allow educators to share information with colleagues and parents (e.g., Google Groups, Edmodo, Twitter, LiveBinder, Symbaloo, and Google Docs). AT has come a long way in the past 30 years with the development of many more educational technology tools to meet a wide range of student and professional needs.

General education initiatives in support of No Child Left Behind (NCLB, 2002) and Response to Intervention (RTI) (NASDSE, 2005) have raised awareness of students who may have special educational needs, making AT providers more cognizant of a wider range of students who need support. Rose and Meyer's (2002) book, *Teaching Every Student in the Digital Age*, introduced the principles of Universal Design for Learning (UDL) and led to a broader vision of tools and strategies for all students. But responding to the breadth and depth of student needs utilizing the latest technology tools creates new paradigms for AT specialists serving on AT teams. There is an evolving imperative for AT specialists to go beyond a one-student-at-a-time approach and to include an expanded approach to AT service delivery that will address more students. But how do we take on this challenge in the most practical way? How can we leverage new online tools to facilitate this? This article summarizes one school district's approach to extending the reach of AT with a model that serves the needs of more students, supports more staff, creates more natural environments for students who rely on technology in a way that reduces the stigma associated with AT, and decreases the likelihood of AT abandonment.

History of AT in Montgomery County Public Schools

Montgomery County Public Schools (MCPS) is a large, diverse suburban Maryland school district located northwest of Washington, DC. In 1988, MCPS developed an AT team called the Interdisciplinary Augmentative Communication and Technology (InterACT) Team. InterACT focuses on students most affected by their disabilities and, therefore, most in need of technology to surmount barriers, for example, students in need of Augmentative and Alternative Communication (AAC) devices and those with physical disabilities in need of alternate access. The work of this "expert model" of service delivery continues to be critical to serve students with low-incidence, high-impact disabilities, but serves less than 1% of the district's student population.

MCPS created the High Incidence Accessible Technology (HIAT) team in 2003 to specifically ensure that technology is accessible for a broader range of students. From its inception, HIAT staff has been committed to UDL, and strives to promote technology for all—not just some—students. Basic math dictates that an expert model of AT service delivery is not scalable to reach larger numbers of children. Faced with an estimated 10,000 students with identified disabilities, we realized we would need a staff of 200 to maintain an expert model. On top of that, when we examined the statistics for all students in the margins, including speakers of other languages and disengaged students, it became apparent that this totaled at least one third of the district's student population. To reach all students, we needed a different model of AT service delivery. The result of these early discussions was a shift to a capacity-building model of service delivery to address the needs of all students—from a *one* to an *all* approach.

Building Capacity

Moving toward a capacity-building approach to AT required a shift away from the traditional, student-focused referral. The role of the AT specialist on the HIAT Team goes beyond the

Continued on page 20

needs of the identified student to focus on the needs and skills of the school-based team. The HIAT "Request for Support" is an online survey designed to determine the best way to support the school team in identifying needs and implementing strategies for that student and, ultimately, other students. When staff request support from HIAT, they are asked to provide only basic information about the student (e.g., identifying information, age, grade, and educational difficulties in brief). Moreover, the survey asks staff to indicate the degree to which they are comfortable addressing all aspects of AT consideration, are familiar with available AT tools, and can develop AT trial periods and implementation plans for that student. The focus is on the strengths of the local school team who provide daily AT support.

The shift from an expert model to a capacity model of AT service delivery requires that AT service providers communicate shared responsibility. Once a HIAT team member examines the survey results, a phone call or meeting is scheduled with the student's case manager. Follow-up discussions are an effective way of getting to the heart of particular issues and building collaboration. Survey results and talking directly with school staff help the AT specialist confirm the knowledge level and experience of the Individualized Education Program (IEP) team, obtain central clarity on the issues, and make joint decisions on the types of services needed. This approach also serves to set the expectation that school staff are to conduct as much of the AT consideration process as possible. HIAT staff determines which components of AT consideration the team can complete independently, and then guides and provides modeling in the areas needed. HIAT mentors staff to use the popular SETT framework, a four-part model that promotes collaborative AT decision-making (Zabala, 2005). HIAT staff coach teams, as needed, to provide training on AT tools or to support the school team to create appropriate documentation for the student's record. The role of the HIAT AT specialist is designed to increase the capacity of school-based staff using a form of triage to build on the school team's expertise and match services to current needs. The HIAT team continues to deal with one-student-at-a-time demands but with a more capacity-building mindset.

New Approaches to Delivering AT Services

Changes in the ways we document AT services were necessary to reflect our commitment to building capacity. Instead of merely documenting the total number of student referrals, we document the type and amount of service provided for each request for support. Do school teams need all types of services, beginning with the SETT meeting right through the development of an implementation plan? Do they need support with AT assessment? Or, do they more often just need consultation on appropriate tools or the development of a trial period or implementation plans? These decisions are tailored to individual school teams and data is collected to document the types of AT services provided. The total number of each type of support to teams is reflected in an end-of-year report (Figure 1).

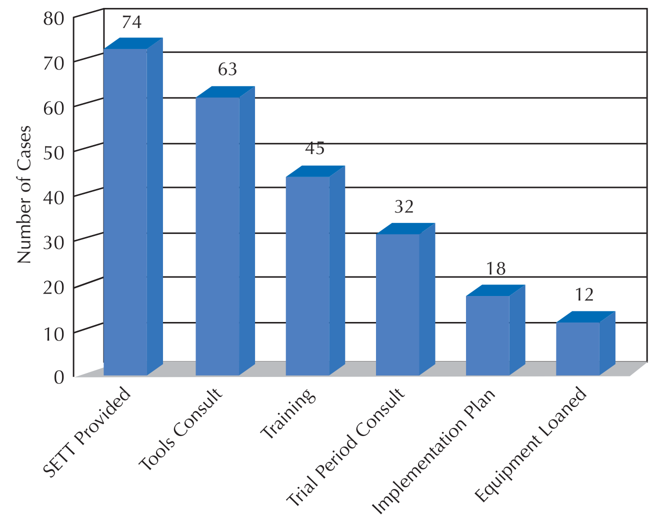

Figure 1. Frequency of the components of the AT consideration process supported by HIAT from January through June 2013.

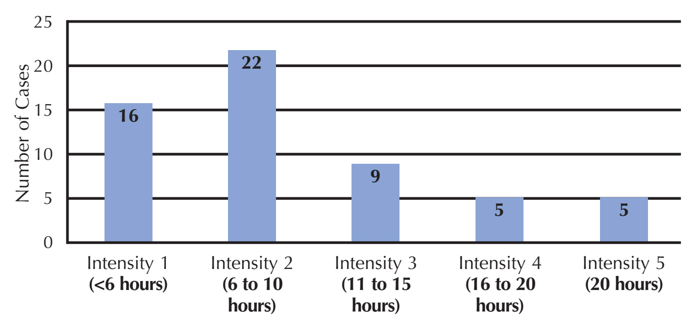

Figure 2. Total intensity of support provided by HIAT to school teams.

As the HIAT team builds capacity, we expect to see a decrease in the number of schools that need the full range of AT services. HIAT's overarching goal is to continue to build the expertise of local school staff to carry out all aspects of the AT consideration process, and yet, be comfortable in contacting the team with questions and concerns. For example, in schools where the SETT process has been modeled previously by the HIAT team, school teams demonstrate an increased comfort level in their ability to analyze students' needs, learning environments, and learning tasks, but then contact the HIAT team to check on appropriate AT tools or discuss the structuring of an AT trial period. This mentoring approach also applies to AT assessment, whereby the team coaches or provides online training to school staff to administer the Written Productivity Profile (DeCoste, 2005) and the Protocol for Accommodations in Reading (DeCoste & Wilson, 2012) to make informed decisions about reading and writing accommodations for students with high incidence disabilities. In this way, teachers gain skills that can be applied to more students.

At the conclusion of every school year, we document the amount of time we spent providing support to school teams (Figure 2). This amount of time is categorized in levels of "intensity." Our goal is to be able to support more teams at a lower level of intensity. End-of-year data measuring school team satisfaction combined with shifts in the levels of intensity of services provides evidence of the team's ability to effectively deliver AT services.

Building On-Demand Resources

To build AT capacity, on-site school consultation is necessary but not always sufficient. There has been a shift from the exclusive use of one-to one, face-to-face (f2f) training, to providing support through the development of on-demand, online resources. Given the small size of the HIAT Team (4 professional staff totaling 3.5 full-time equivalent positions) and the need to cover 200 schools, finding ways to more efficiently provide support has been imperative. Over the years, the HIAT team built a wide array of online resources using a variety of digital productivity tools (Figure 3). Printable quick guides, segmented video tutorials, FAQs, a help blog, implementation roadmaps, and quarterly newsletters have been developed to provide just-in-time support. Google groups and social networking tools are used to share information. A team dictum is that if a particular question is directed to HIAT staff more than once, then an online resource is needed, and all HIAT Team members contribute to its development. Today's AT specialists not only need to be knowledgeable in assistive technology but also skilled in web development and social networking.

FIGURE 3. Productivity and Networking Tools

Digital Tool	Purpose
Relational database	To track student data and school services
Web development software	To post online information
Online survey tool	To request consultation To request professional development Provide feedback on service and training
Video, screen capture	To create online training videos
Webinar software	To provide live and asynchronous training and support
Networking tools	To provide opportunities to share ideas and strategies
Online course management software	To structure online courses and support PLCs
Blog site	To post help tips
Word processing template	To efficiently assemble an end-of-year report

Expanded Models of Professional Development

Professional development (PD) is another area of change for the AT profession. For the past 6 years, the HIAT team sponsored as many as 87 to 159 scheduled, group f2f workshops per year. This training was possible due to a concerted effort to build the capacity of teachers and related service professionals district wide to plan and deliver high quality training. HIAT developed the E-TIPS program (Educators Using Technology to Improve the Performance of Students), in which educators are recognized as E-TIPS Educators after accruing 75 hours or more of technology training. E-TIPS Educators are encouraged to promote knowledge of AT at their schools, as well as provide f2f training at district levels. Initially, E-TIPS Educators co-train with HIAT staff and then progress to independently providing f2f workshops.

Workshop topics have evolved over time. Compared to six years ago, the needs for training are shifting from introductory topics offered in a central location for the entire district, to customized topics offered at schools or department meetings. Most of the professional development delivered by HIAT staff today is a response to specific requests. Established groups such as academic departments, special education departments, and school teams can complete an online survey to request professional development on UDL practices or succinct technology-related topics.

F2f training, however, is not always practical given the time and cost to travel to a training site, a teacher's time away from the classroom, and competing after-school priorities. And, 2 to 3-hour f2f trainings are often overwhelming or inadequate for staff who are learning new technology-based skills. The HIAT team began to examine the need for multiple means of accessing professional development to better address a wide selection of AT related topics for a wide range of adult learners. We examined current and future training topics and evaluated the ways in which these topics could be modified to online, on-demand resources such as live webinars, recorded webinars, interactive video tutorials, and online courses (Figure 2). Today, AT specialists, regardless of whether they are solo AT service providers or work as part of AT teams, need to be experts in distance learning, as well as scripting, to create video resources to maximize and deliver on-demand support.

Outreach and Collaboration

As the HIAT team's website of resources grew it became easier to respond quickly to questions regarding hardware, software, and strategies for implementation. The team is able to provide more support to more staff in more efficient ways. This efficiency allows the team to spend more time on much needed outreach. In order to build capacity, it became clear that we had to reach out to other departments to advocate for change that would benefit a wide range of learners. For example, we met with curriculum developers to discuss the need to incorporate UDL principles into the online curriculum and to promote relevant choices and flexible options within the curriculum and create lesson-planning tools that incorporate UDL elements. Subsequently, an AT specialist was hired full time to work with curriculum developers for 3 years to ensure that

Continued on page 22

UDL was incorporated into elementary model lessons. In the MCPS Elementary Integrated Curriculum, teachers now have active links to digital materials to provide instruction to a wide range of learners. Additionally, we initiated an AT steering committee that meets quarterly to discuss a range of technology issues such as equitable access to free text-to-speech tools, the development of a year-long protocol to approve and install new AT software, and the development of "functionality checklists" to ensure that AT software is in working order. Current topics include issues of accessible instructional materials and equitable access to accommodations for testing. Likewise, the team is working with media specialists who make decisions regarding media subscriptions and instructional materials to identify specific UDL criteria to guide district and school-level purchasing of paper, digital, and online instructional materials that would support a full range of learner variability and multiple levels of content understanding. To ensure the availability of technology to benefit a wide range of learners, it is imperative for AT specialists to share their expertise and actively reach out to key staff in various departments who can help build this capacity within a framework that addresses the needs of all students.

Bringing UDL to Scale Through Job-Embedded Learning

UDL has been the guiding philosophy from the inception of HIAT. UDL principles are integrated into all HIAT professional development. Over time, the "word" on UDL has filtered up and down the district ladder. This generates more requests for building UDL awareness as part of district-level training. For four consecutive summers, the UDL framework has been incorporated into mandatory summer training for general education and special education teams. It has been integrated into professional development on co-teaching. Teacher-by-teacher, department-by-department, and school-by-school, knowledge of UDL is growing.

After years of building an awareness of UDL principles across the district, the next logical step was to focus on the systematic implementation of UDL in schools. At the time, there was little to guide UDL implementation. Using the work of Fixsen, Naoom, Blase, Friedman, & Wallace (2005), as well as texts on effective staff development (Fogarty & Pete, 2007; Schmoker, 2001; Sparks and Hirsh, 1997) and building professional learning communities (PLCs) (DuFour, DuFour, Eaker, & Many, 2006; Roberts & Pruitt, 2003), the HIAT team worked initially in 2009 with selected teachers in one elementary school and one middle school focusing on the implementation of UDL in targeted classrooms. Over a 5-year period, this work has expanded to 13 elementary schools, 10 middle schools, and 1 high school. School staff must apply to participate on UDL PLCs and are selected based on their leadership ability and willingness to commit to a full year, online course that provides the structure for the UDL PLCs' activities and discussions. Classroom observations using UDL rubrics and self-reflection surveys are two of the tools used to promote accountability and provide feedback.

By coaching UDL PLCs, the HIAT team's purpose is to improve access to technology to support a wide range of students. This practice has resulted in some very satisfying and unexpected outcomes. General educators effectively implementing UDL report that putting in the time up front to plan lessons with UDL in mind saves time because it enables them to reach more students. By establishing UDL routines that incorporate flexible options and student choices, teachers report fewer challenging behaviors and increased student independence. Principals frequently note that students who were typically disengaged are more actively participating in classroom activities.

Another unexpected outcome is the backing of parents of students with special needs, even though the focus of UDL implementation is on general education. From the start, MCPS parents have been vocal advocates of UDL. Parents of special education students appear to appreciate that changes to overall classroom practices have the potential to positively affect participation—that using the IEP process to mandate inclusive practices was necessary but insufficient. Dr. Carol Quirk, co-executive director of the Maryland Coalition for Inclusive Education, states, "Once general educators become comfortable with the use of UDL practices, a wider range of students can naturally access and learn the curriculum. Consequently, 'including' students with disabilities in instruction becomes a way of conducting educational business" (personal correspondence, May 8, 2013).

Our goal is not to tell educators how to teach, but to give them essential information on UDL, provide ongoing coaching, and engage in cooperative learning. Through this process, members of the PLCs are challenged to create their own exemplars of how UDL is expressed in the classroom and share this with colleagues. Incorporating UDL into daily classroom instruction is a recursive process whereby teachers use the UDL framework to plan and execute learning activities, then analyze student outcomes, including any evidence of "who got left out." Subsequently, teachers re-evaluate and modify strategies to ensure that all students are learning. Lesson plans that incorporate flexible options including technology are more engaging, such that students who rely on AT do not feel singled out, and consequently, this lessens the likelihood of AT rejection.

The central message continues to be that UDL is not something that you do; it is a way that you think about what you do. Planning with UDL in mind is a message that has been shared in many ways with general and special education leaders. The work of the HIAT team is to share effective classroom strategies that incorporate technology across the district. The HIAT website provides access to information, resources, and video examples of successful UDL practices. However, efforts to implement UDL should not be owned by special education, nor by assistive technology teams. In MCPS the impetus to address UDL may have begun with the efforts of the HIAT team, but early collaboration with general education on many levels has been crucial. Professional development on UDL to teams of general and special educators was often co-taught, underscoring the message of working across the aisles. The availability of digital text via the district's online curriculum and the selection of online media subscription tools that have UDL features, such as leveled text, text-to-speech, images, video, and dictionary support are examples of the district's support of UDL principles. UDL is a framework that must be adopted top-down and bottom-up.

Visioning and Accountability

Each year, the HIAT team reflects on the bigger picture of technology for all students. Mid-year, the team meets for a full day to analyze critical issues pertaining to AT and begins to plan for the following school year. Databases are used to collect information throughout the year. At the conclusion of the school year, HIAT creates a comprehensive report on annual progress. This serves to keep the team focused and accountable by documenting what has been done to move toward the attainment of AT integration. Yearly visioning coupled with accountability keeps us on track. Furthermore, the annual report also strengthens team credibility and documents alignment with district goals. Each year, the team's vision is influenced by identifying barriers, large and small, that serve as hurdles to the provision of technology support to a wider range of students. Building technology integration for all students requires courageous conversations about the role and responsibilities of AT service providers to support systems change. It requires ongoing communication with administrative leaders, capitalizing on shifting initiatives and funding opportunities within the district, and perseverance to foster changes in educational practice.

The Changing Role of AT Teams

Assistive technology is not a one-size-fits-all approach. With new digital tools and the motivation to allow more students to access those tools, the HIAT Team has forged new paths for the delivery of AT. The team developed a triage approach to service delivery for students with high incidence disabilities that acknowledges the knowledge level of the local school team, regardless of the starting point, and pinpoints current need relative to individual students. It has expanded beyond a one-student-at-a-time approach to deliver just-in-time resources and strategies that are valuable to staff and suitable to all students. Using new productivity and networking tools, we have built digital online resources and expanded methods of delivering professional development. With the support of MCPS, the team has developed a broader continuum of AT services focusing on building capacity to reach more students. We reached out to general educators and district leaders and developed professional learning communities that emphasize the UDL framework to promote natural learning environments that incorporate AT. We committed to moving outside of our AT comfort zone and pressed for changes that would make technology more accessible to all students.

While not all students require AT, those who do require AT depend on it to participate and grow academically. AT teams have served these students staunchly for more than two decades. However, there is a wider range of students who can benefit from daily access to technology than have typically been served by AT teams. Small AT teams can have a larger impact if they use available productivity and networking tools to build the capacity of educators to reach more learners and more broadly conceptualize the role of AT teams within their school district.

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Resources

Montgomery County Public Schools, Maryland, High Incidence Accessible Technology (HIAT) Team: http://www.montgomeryschoolsmd.org/departments/hiat/

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Continued on page 24

 continued from page 23

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Disciplinary Literacy and Technology for Students with Learning Disabilities

by Cynthia M. Okolo and Rachel A. Kopke

Expectations for content-area learning have risen over the past several decades, as currently reflected in reforms such as the Common Core State Standards (CCSS). Consequently, education has developed an increasing sensitivity to the way information is structured, the nature of discourse, the process of inquiry, and the standards one uses to evaluate information in different disciplines. Although various disciplines share many common features, they also display important differences. For example, a historian has to consider multiple sources and perspectives that may be incomplete and contradictory, leading to conclusions that are borne of scholarly interpretation. Learning history, then, is different from learning mathematics—in which information is more factual and well specified with less room for interpretation. This example highlights the nature of *disciplinary literacy*—an approach to literacy that takes into account the characteristics of the discipline and the literate practices in that discipline (e.g., Lee & Spratley, 2010; Moje, 2008; Shanahan & Shanahan, 2008).

In the current educational climate, the acquisition of disciplinary literacy becomes an important consideration for students with learning disabilities (LD). Typically, explicit teaching or cognitive strategy instruction has been employed to address the difficulties that students with LD face in learning content. These more generic approaches to content area learning ignore, to a large extent, the specialized knowledge and skills that underlie disciplinary expertise (Okolo & Ferretti, 2013). This is not to say that more generic approaches to literacy in the disciplines are not necessary and important (Faggella-Luby, Graner, Deshler, & Drew, 2013). Rather, they may not be sufficient for helping students with LD acquire the skills and understandings that are at the heart of disciplinary literacy (Shanahan & Shanahan, 2012).

Differences in Learning Across the Disciplines

Before presenting examples of how technology can support the acquisition and use of disciplinary literacy skills among students with LD, it is important to review some of the characteristics of three of the content areas that comprise the K–12 school curriculum: science, social studies, and mathematics. For the purposes of this article, we will focus specifically on history to represent the discipline of social studies.

Disciplines have different characteristics in regard to the nature of knowledge that falls under their purview and the way in which that information is organized. An understanding of these differences is important when choosing technology tools that can support disciplinary literacy. Briefly, and at the risk of oversimplification, K–12 science focuses primarily on the discovery, though hypothesis and experimentation, of generalizable core principles that explain natural phenomenon. History is an interpretive endeavor that strives to cultivate an understanding of the role of individual, group, and other larger factors over time. And, mathematics is principally a deductive enterprise in which well-established, generalizable principles are applied to specific examples of interest (Boix-Mansilla, 1995; Lee & Spratley, 2010; McConachie & Petrosky, 2010; Shanahan & Shanahan, 2008; Moje, 2008; Schwab, 1978).

Disciplinary Literacy and Students with Learning Disabilities

Given these disciplinary differences, it is not surprising that the foundational knowledge and vocabulary students need to succeed, as well as demands for reading, writing, and investigating, differ in each of these areas. Becoming literate in multiple disciplines is a highly ambitious goal for all students, and especially for students with LD.

Special educators are well aware of the difficulties that students with LD encounter in mastering basic reading and writing skills (e.g., Lovett, Barron, & Frijters, 2013; Vaughn, Swanson, & Solis, 2013). Developing proficiency in a discipline demands that students build a strong foundation of specific knowledge and acquire specialized vocabulary. The reading difficulties of students with LD constrain the extent and richness of their vocabulary and background knowledge (e.g., Bryant, Goodwin, Bryant, & Higgins, 2003). These limitations inhibit the development of interconnected networks of knowledge that characterize disciplinary experts (e.g., Bransford, Brown, & Cocking, 1996; Rouet, Favart, Britt, & Perfetti, 1997). Weak literacy skills, in addition to difficulties with application and generalization, increase the challenge of disciplinary learning. Finally, mastering different processes and standards of inquiry adds even more complexity for students who struggle with reasoning and problem solving (Johnson, Humphrey, Mellard, Woods, & Swanson, 2010).

Disciplinary Literacy and Technology

Technology can support all students in meeting the challenges of disciplinary literacy. For students with LD, technology can *compensate* for at least some of the difficulties and challenges described above. Other articles in this issue (e.g., Erickson; Winters & Cheesman) discuss ways in which technology can provide access to text and promote comprehension and communication for students who have literacy disabilities. Commonly used technology features, such as text-to-speech, word prediction, and vocabulary support, are important additions to disciplinary learning. Although we will not address technology tools that compensate for disabilities at the level of word recognition, fluency, and basic writing in this article, we will discuss how common technology-based literacy tools can be used, in specialized ways, to enhance students' learning in the disciplines.

Continued on page 30

Additionally, technology provides a set of tools that *enable* disciplinary literacy. We avoid using the term *scaffold* here because many of these tools are not ones that should be gradually taken away from students. Just as we would not expect a historian to work without reference management software, or a microbiologist to work without a digital microscope, many technology-based disciplinary tools are necessary ones that provide access to background information, routinize lower-level tasks, and facilitate more sophisticated inquiry.

Below, we offer examples of both compensatory and enabling technology-based tools. We situate our discussion of these tools within five components of disciplinary literacy: 1) foundational knowledge, 2) specialized concepts and vocabulary, 3) critical reading, 4) inquiry, and 5) writing. Each of these five components represents a set of knowledge, skills, and performances that is at the core of disciplinary literacy, and each varies at least somewhat within disciplines. Although not an exhaustive list, Table 1 displays some of the technology tools available to support disciplinary literacy, along with a brief description of how each could be used. Many of these tools are addressed in the sections that follow.

Foundational Knowledge

Although the primary instructional goals for disciplinary literacy focus on deep understanding and application of knowledge, studies of expert-novice performance show that expertise builds upon a rich and inter-connected foundation of key facts, concepts, principles, and explanatory frameworks in the discipline (e.g., Bransford, Brown, & Cocking, 1999; Shulman, 1986). For example, accomplished scientists have a well-developed knowledge of scientific concepts and the scientific process. Historians use their knowledge of names, dates, chronology, and the significance of specific events and individuals in service of interpreting historical information. Mathematicians have a strong command of basic mathematics concepts, algorithms, procedures, and processes.

Technology can both compensate for gaps in foundational knowledge and offer avenues for expanding and extending the knowledge one possesses. In fact, it is difficult to imagine a world in which we would not use technology to access foundational knowledge to support our everyday and academic endeavors.

Discipline-specific *internet portal sites*, which provide links to information by topic, can help students more easily acquire background knowledge. For example, *History Matters (http://historymatters.gmu.edu/browse/wwwhistory/)* provides a list of websites—which are screened, selected by historians, and annotated—of United States history topics and time periods.

The Web also offers numerous sites on which students can view brief *video clips*. Some support background knowledge (e.g., *Teacher's Domain*), whereas others provide tutorials and lessons (e.g., *Kahn Academy*). For many students with LD, brief videos such as these are not sufficient substitutes for more comprehensive instruction. However, they are resources that may help students develop foundational knowledge about unfamiliar topics.

Virtual manipulatives and simulations can provide instructive and exploratory experiences that support the development of conceptual knowledge underlying disciplinary topics, particularly in mathematics and science. They can also provide opportunities for hypothesis testing and experimentation during disciplinary inquiry. Finally, tools such as Google's built-in calculator or *Wolfram Alpha*, support both foundational knowledge and enhance inquiry by reducing some of the cognitive and memory burdens of lower-level computational skills.

Specialized Concepts and Vocabulary

A quick internet search will yield lists of key concepts and vocabulary in each of the disciplines. In addition to the specific words that constitute the corpus of each discipline, concepts and vocabulary within a discipline often share specific characteristics. For example, mathematics vocabulary is often technical and abstract in nature. Vocabulary and concepts in history are not as technical as those of mathematics, but everyday words may be used in specialized ways to represent more general ideas. Mathematics also often relies on symbolic representations (symbols and equations) to convey key ideas.

Technology tools that help students acquire and expand their understanding of specialized concepts and vocabulary include common reference tools that are available within software, apps, and web browsers. These include reference sites (e.g., Wikipedia), online dictionaries, thesauruses, and translators (for English language learners). Hand-held technologies, such as the *Reading Pen*, scan and read text but also offer definitions of unfamiliar words in the scanned text. Visually oriented vocabulary tools, such as the *Visual Thesaurus*, offer definitions and demonstrate how the words are interrelated, a feature that may expand students' understanding of the interconnections among concepts and vocabulary in a discipline.

Critical Reading

Reading is a central activity across the disciplines. Although contextualizing information, taking into account its source, and corroborating across texts is important to all disciplines (Shanahan et al., 2011), the ways in which disciplinary experts interact with text and what they attend to within text varies. For example, given the fast pace at which a scientific specialty evolves, scientists are more likely to pay attention to the recency of information than are historians. A historian reads with an eye toward corroborating any particular text with other texts and noting, resolving, discounting, or incorporating discrepancies in different accounts. In contrast, the mathematician is more likely to focus on the integration of new information with his or her prior topical knowledge (Shanahan et al., 2011).

Print remains a central medium for accessing and conveying information in the disciplines, and the technology applications discussed in other articles in this issue, including text-to-speech and supported text, are essential tools for

TABLE 1. Tool and Examples

Internet Portal Sites (all subjects)	**Annotation Tools** (all subjects)
Science: http://sciencenetlinks.com/ **History:** http://historymatters.gmu.edu/browse/wwwhistory/) **Math:** http://www.greatmathsteachingideas.com/2011/01/16/the-10-best-maths-teaching-resource-websites/	**ReadWriteGold:** http://www.readwritegold.com/ **Kurzweil:** http://www.kurzweiledu.com/default.html **PDF reader/markup apps:** http://appadvice.com/appguides/show/pdf-annotation
Video Clips (all subjects)	**Digital Timelines** (history, science)
Science: National Geographic Video Library: http://video.nationalgeographic.com/video/ **History:** Teacher's Domain http://www.teachersdomain.org/browse/?fq_hierarchy=k12.socst.ush **Math:** Khan Academy (math): https://www.khanacademy.org/ **All subjects:** Discovery Education Streaming Videos: http://www.discoveryeducation.com//administrators/curricular-resources/?homepage-streaming	**Dipity:** http://dipity.com **Xtimeline:** http://xtimeline.com/index.aspx **Timetoast:** http://www.timetoast.com/ **Concept Mapping** (all subjects) **Inspiration & Kidspiration:** http://inspiration.com **Bubblus:** https://bubbl.us/ **Text2MindMap:** http://www.text2mindmap.com/ **Wisemapping:** http://www.wisemapping.com/
Computational Tools (math)	**Research and Reference Management Tools** (all subjects)
Google's search calculator: http://google.com (type an equation into the search bar) **Wolfram Alpha:** http://www.wolframalpha.com/	**Diigo:** https://www.diigo.com/ **Evernote:** https://evernote.com/ **Delicious:** https://delicious.com/
Vocabulary Tools (all subjects)	**Collaboration Tools** (all subjects)
Visual Thesaurus: http://visualthesaurus.com/vocabgrabber **Lexipedia:** http://www.lexipedia.com/ **MathWords:** http://www.mathwords.com/ **Reading Pen:** http://wizcomtech.com	**Collaborize:** http://www.collaborizeclassroom.com/ **Google Docs:** https://drive.google.com/
Virtual Manipulatives (math, science)	**Writing Support Tools and Templates** (all subjects)
National Library of Virtual Manipulatives: http://nlvm.usu.edu **Virtual Biology Lab:** http://simbio.com/ **Science Online:** http://www.sciencecourseware.com/ **Gizmos:** http://www.explorelearning.com/	**Write Online:** http://www.cricksoft.com/us/home.aspx **WYNN:** http://www.freedomscientific.com/lsg/products/wynn.asp **SOLO 6 Literacy Suite:** http://www.donjohnston.com/products/draft_builder/
Prompted Reading (all subjects)	**Transcription Tools** (math)
WYNN: http://www.freedomscientific.com/lsg/products/wynn.asp **Critical Web Reader:** http://cwr.indiana.edu **ReadWriteThink:** http://www.readwritethink.org/ **Science Writer:** http://sciencewriter.cast.org **Strategy Tutor:** http://www.cast.org/learningtools/strategy_tutor/	**Apollonius Interactive Geometry Software:** iTunes Store **Panther Math Paper:** iTunes Store **Math Type:** http://www.dessci.com/en/products/mathtype/

disciplinary study. *Prompted reading tools*, such as *Science Writer*, can help students adopt different styles of reading. They may also provide discipline-specific lenses to focus students' critical reading (Damico, Baildon, Exter, Guo, 2009). The *WYNN* literacy software program (Freedom Scientific) has a built-in suite of prompted reading and writing support tools based on a content-area reading strategy that can guide students as they read, study, and write about disciplinary text.

Annotation tools include highlighting, bookmarking, and verbal and text-based notes that can be inserted into or added to text and PDF files. Students can highlight and annotate text as they read to support comprehension, writing, and inquiry. Or, teachers can insert information for students to guide discipline-specific considerations. These types of tools are standard features of many commercial literacy software programs, including Microsoft Office and Adobe Acrobat, and are also available as free or low-cost apps or web-based tools.

Tools such as concept mapping, outlining, and timelining software, websites, and apps are highly flexible and multipurpose options that can be used to facilitate many aspects of disciplinary learning. They can support students' comprehension of disciplinary texts by helping them organize and connect main ideas and details. The representations they help students create can also guide subsequent inquiry and writing.

Continued on page 32

Inquiry

Asking and investigating relevant questions is a hallmark of disciplinary literacy. Although all disciplines follow a systematic process for inquiry, the specific actions taken, the value of different types of evidence, and the standards used to judge the results of inquiry differ. Scientific inquiry emphasizes hypothesis testing and careful observation and documentation. Historical inquiry also requires careful documentation, but the historian must take into account issues such as bias, representativeness, and context when drawing conclusions. Mathematical inquiry, on the other hand, is often focused on patterns and regularities that can be applied across multiple examples (Shanahan et al., 2011).

Research and reference management tools are indispensable for collecting, organizing, and documenting research in many fields. There are several free and sophisticated tools available, such as *Diigo* or *Evernote*, with features that permit students to input information, from multiple sources, that can be tagged, bookmarked, highlighted, and annotated. Students will most likely need explicit instruction to make use of these features during the inquiry process. Collaboration is also an important aspect of inquiry, and collaboration tools enable students to share data, publicly represent ideas, and jointly construct products that demonstrate their inquiry results.

Writing

Communicating one's findings and conclusions, and contributing to information and scholarly debate, are important byproducts of disciplinary activities. The structure of the discipline, as well as the nature of inquiry within it, leads to differences in the form and nature of disciplinary writing. For example, scientific writing often focuses on description and explanation. Historical writing privileges argumentation. In mathematics, symbols are often as important as words in communicating key ideas and conclusions.

Other articles in this issue (e.g., Edyburn; Winters & Cheesman) have discussed the tools in literacy software programs, such as spell checking and word prediction, which can support both routine and higher-level writing tasks. *WriteOnline* (Crick Software) has a feature that enables teachers to create wordbars with specialized or discipline-specific vocabulary. Wordbars can be used to support and build vocabulary knowledge and facilitate the use of disciplinary terms and concepts in writing. As discussed earlier, the representations provided by concept mapping, outlining, and timelining programs can organize ideas for writing. Programs such as *Draft:Builder* (Don Johnston) offer editable writing templates that can be adapted to different types of writing. Finally, given the symbolic nature of writing in mathematics, specially designed transcription tools can assist students in representing their ideas and concepts.

Conclusions

The acquisition of disciplinary literacy poses new challenges for students with LD. Reading and writing difficulties are compounded by expectations that students adapt specialized ways of reading, reasoning, and writing that vary across disciplines. Multi-purpose tools such as text-to-speech, enhanced digital text, word prediction, and speech recognition can support students with LD, as can discipline-specific computational tools, transcription tools, and virtual simulations and manipulatives. Disciplinary internet portals and video libraries can help build background knowledge and support vocabulary. Literacy software and apps can be tailored to support reading and writing from a specific disciplinary perspective. Finally, a variety of research, reference management, and collaboration tools can support students' disciplinary inquiry.

Disciplinary experts rely on technology for their own learning and scholarship and, thus, it is likely that tools that can be used or adapted for K–12 education will continue to increase. However, technology to support disciplinary literacy also resides in the many multi-purpose software programs, web-based options, and apps that students use for more general school activities. An increasing number of these tools are free or available for minimal cost. Educators will play a key role in developing and sharing innovative ideas and examples of how commonly available technology tools can be adapted for the goals and activities of a specific discipline.

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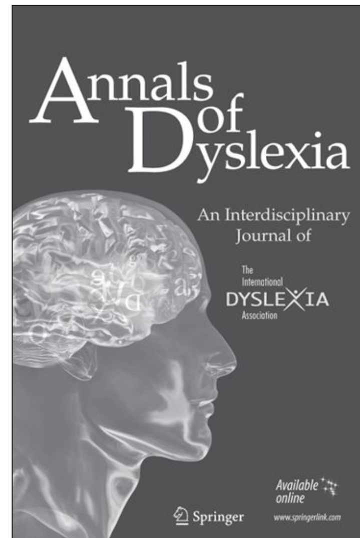

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Assistive Technology and Writing

by Dave L. Edyburn

Children's development as writers has been studied extensively (Clay, 1979; Graves, 1983; Merchant, 2006; Tolchinsky, 2006). As a result, the research offers clear milestones for parents and teachers to observe a child's writing development and concepts of print. As summarized in Table 1, children's initial efforts to write involve learning to grasp writing instruments and scribbling. As children physically mature, they develop the fine-motor skills to properly hold a writing instrument and manipulate it with some control. Later, their cognitive development enables them to notice features of text, such as straight lines and curves, which they try to imitate as they work toward tracing and copying letters. During the preschool years, children develop to the point where they are able to print letters and numbers from memory (without a model to copy). Learning to write one's name is a significant milestone that typically occurs around ages 4 to 6. As children continue to learn to write and spell simple words, writing begins to provide a functional purpose.

Children with disabilities are likely to be developmentally delayed in achieving each of the milestones described above. For many children with significant disabilities, "developmental delays in communication, language, cognition, physical mobility, social skills, and play skills present challenges to becoming literate" (Sadao & Robinson, 2010, p. 123). As a result, it is important to be attentive to barriers that prevent any child from accessing and engaging in the emergent literacy activities appropriate for their peers. Assistive technology (AT) should be explored whenever a child encounters significant barriers that prevent him or her from accessing and engaging in developmentally appropriate learning activities.

The provision of AT devices and services is predicated on the need for interventions that overcome a performance problem encountered by an individual with a disability (Blackhurst, 2005; Cook, Polgar, & Hussey, 2008). For individuals with learning disabilities (LD), in the context of expectations for writing, AT may be sought to provide access to preliterate writing activities such as scribbling, copying letters, and writing one's name. Or, it may involve interventions that seek to compensate for poor handwriting by altering the task from writing by hand to keyboarding or dictation.

Table 2 illustrates a range of strategies and technology tools that might be used by students who struggle with the physical process of text production (Edyburn, 2013). In general, these types of problems and interventions are quite common in the field of AT (Sadao & Robinson, 2010; Sitko, Laine, & Sitko, 2005). One explanation points to the preponderance of occupational therapists involved in the evaluation and provision of AT. Occupational therapy interventions tend to involve therapy to teach or reteach handwriting skills or provide instruction on how to use compensatory approaches to overcome access barriers associated with poor fine motor skills.

However, in the new age of Common Core State Standards (CCSS) for English Language Arts (ELA) *(http://www.corestandards.org/the-standards/download-the-standards)*, the term *writing* refers to much more than the physical act of writing on paper. Writing is viewed as a complex metacognitive skill that requires an individual to express him or herself in a manner that makes thinking visible (Torrance & Galbraith, 2006). The importance of helping students achieve higher writing standards has contributed to a variety of new resources to assist teachers in designing classroom writing projects that incorporate technology and writing strategy instruction to meet the new ELA standards (Herrington, Hodgson, & Moran, 2009; Hicks, 2013; National Writing Project, 2010; Owocki, 2013; Stephens & Ballast, 2010).

Since diverse students in every classroom will demonstrate a range of skills, abilities, and weaknesses relative to writing, one promising tactic for providing technology tools for students with LD involves embedding support tools into the curriculum using principles of Universal Design for Learning (UDL) (Rose & Meyer, 2002). That is, the kinds of tools that have been found useful for helping some students with disabilities who have

TABLE 1. Preacademic Milestones in Children's Development as Writers

Preacademic Skill	Impact on Academic Skill
Child grasps writing instruments; scribbles	Child learns that writing instruments produce marks
Child holds writing instruments with fingers; scribbles	Child develops fine motor skills and intent to communicate
Child imitates specific strokes in isolation	Child learns skills necessary for forming letters
Child traces or copies from models that combine strokes to form letters or numbers	Child learns how to produce forms that can be recognized as letters or numbers
Child writes letters or numbers without a model	Child learns to produce letters without a model
Child writes letters in combination; left to right sequence	Child learns to write complete words

Adapted from: Edyburn, 2013, p. 268.

TABLE 2. Assistive Technology Interventions for Students Who Struggle to Communicate in Print Because of Difficulties in the Handwriting Process		
Instructional Challenge	**Strategy**	**Technology Options**
A student has difficulty writing legibly and/or efficiently.	Provide an adapted writing instrument such as a pencil grip.	The Pencil Grip http://www.thepencilgrip.com/
	Allow the student to keyboard assignments instead of writing by hand.	Handheld computer Laptop computer Tablet computer
	Use speech to text tools (dictation) to bypass the hand-generation of text.	Dragon Naturally Speaking http://www.nuance.com/dragon/
		iDictate http://www.idictate.com
		Speak-Write http://www.speak-write.com

difficulties with writing may also have application for many other students. Since we do not typically know in advance which students will benefit from which tools, it is appropriate to introduce all students to a wide range of tools and observe how the tools affect academic performance.

For some students, technology tools will serve as a temporary scaffold to be abandoned once the skill is acquired and developed to a level of automaticity. Other students may become reliant on the tool finding that they need a specialized tool whenever they complete a specific task. Whereas some educators and parents may find this dependency alarming, we must remember that all professionals are dependent upon some sort of productivity tool (i.e., carpenter–hammer; scientist–microscope; accountant–spreadsheet). The ultimate goal is to aid each student in finding a collection of tools that supports exceptional writing performance so that writing is not viewed as an aversive activity.

Space limitations prevent focusing on the entire writing process and the role that technology can play in supporting struggling writers. As a result, the purpose of this article is to highlight three specific tasks that are particularly troublesome for students with learning disabilities: learning to engage in regular writing, planning, and preparing a first draft. The goal is to provide readers with resources that will inform both research and practice.

Evidence-Based Interventions

Teachers and administrators are increasingly expected to implement evidence-based practices in the classroom as a tactic for raising academic achievement. Therefore, it is relevant to briefly summarize the research concerning effective writing instruction (see Table 3). Understanding general principles about effective writing instruction established through research will help teachers utilize tools effectively when there is an absence of research about the efficacy of a specific technology product.

Teachers and administrators interested in accessing the latest research findings are encouraged to consult What Works Clearinghouse *(http://ies.ed.gov/ncee/wwc/)* and the practical companion website: Doing What Works *(http://dww.ed.gov)*. Additionally, recent meta-analysis syntheses by John Hattie (2012) provide an accessible guide for teachers and administrators interested in interventions that positively impact student academic achievement.

Continued on page 38

TABLE 3. Summary of Research Concerning Effective Writing Interventions	
Research Findings	**Source**
Meta-analysis demonstrated a medium effect size (d=0.50) when students used technology in their writing; gains significantly greater than when they wrote using paper and pencil.	Goldberg, Russell, & Cook, 2003; MacArthur, 2009
Teachers need to provide specific strategy instruction if students are going to improve their writing.	Gersten & Baker, 2001; Graham, MacArthur, & Fitzgerald, 2013
Large effect sizes have been found for writing instructional programs that involve collaboration with teachers (d=0.76) and with peers (d=0.70).	Gersten & Baker, 2001
Assistive technologies that provide alternative access to writing are helpful for some students.	MacArthur, 2009

TABLE 4. Instructional Technology Interventions for Daily Writing

Instructional Challenge	Strategy	Technology Options
Students are unable to focus their attention and mind to engage in writing.	This site provides a single word prompt; the writer has 60 seconds to write about it.	Oneword http://oneword.com/
	This site sends you a friendly email asking, "How did your day go?" that serves as a daily writing prompt.	OhLife http://ohlife.com/
	This site is a free online digital journal. Daily journaling is a great way to develop writing skills.	Penzu http://penzu.com/
	This site sends a weekly creative writing challenge. Students are asked to write a 100-word response that is posted to a public blog.	100 Word Challenge http://100wc.net/

Developing the Mindset to Write Daily

To develop the cognitive skills to transfer ideas from the mind to paper or screen, teachers often engage students in a daily writing task such as journaling or responding to prompts or story starters. Table 4 provides a variety of technology-based strategies and tools for helping students develop the mindset for practicing short periods of daily writing.

Over time, daily writing practice helps writers develop their skills and confidence in ways that silence the critic inside of their heads. The long-term benefit of daily writing activities is to help students acquire the skills necessary to think, compose, and organize their thoughts, and capture them on paper or screen. Whereas teachers and parents may be tempted to focus exclusively on the content of the daily writing, the real value of these activities is that they develop habits of the mind that promote thinking and executive functioning. When students regularly engage in the process of writing, they have the potential to develop written fluency through the automaticity of the skills associated with idea generation, handwriting or keyboarding, spelling and punctuation, work habits, and confidence as a writer. Speelman and Kirsner (2005) note that exceptional executive functioning is dependent on the mastery of the discrete skills to free cognitive energy for higher order thinking tasks. As a result, students with LD who fail to achieve success with the component skills, and learn how to integrate them, will find all phases of the writing process to be challenging. Daily writing is an important developmental step in the process of becoming an effective writer.

Planning

Many students mistakenly believe that the majority of time spent on a writing project should be spent on writing a draft. However, when more time is spent preparing to write, the actual time spent writing is often reduced.

Historically, teachers have instructed students about how to use an outline to help them plan their writing. However, most adults readily admit that they waited to write their outline until after they completed writing their paper. Why is that? Jimmy writes the outline for his dinosaur report after he writes the report itself because it is not until *after* the paper is written that he understands the subtopics, sequence, and relationships. It is sad that our parents and grandparents will also admit to writing their outline after their report was completed. Isn't it time we recognize that outlines are a prewriting tool for experts and that novices need different types of tools to plan their writing?

Table 5 summarizes a variety of technology tools that support brainstorming and planning for a writing project. An

TABLE 5. Instructional Technology Interventions for Planning

Instructional Challenge	Strategy	Technology Options
Students struggle to plan the focus of their writing because they do not understand their topic or the subtopics at the outset.	Provide students with digital planning tools that support the active manipulation of visual information.	Cmap http://cmap.ihmc.us/
		Draftbuilder http://www.donjohnston.com
		Inspiration http://www.inspiration.com
		Kidspiration http://www.inspiration.com

important consideration for twenty-first century learners is the use of graphic organizers to brainstorm ideas in a visual format (DiCecco & Gleason, 2002; Grant, 2009; Lorenz, Green, & Brown, 2009; Rock, 2004).

Graphic organizers allow the learner to capture ideas as they emerge and then to alter the organization of the information as he or she gains new insights about the sequence of ideas, relationships, and, ultimately, what to exclude. The visual manipulation of ideas is an active planning process. It should be noted that these tools automatically generate an outline based on the graphic organizer that is created. As a result, students can toggle back and forth between the linear (outline) format and the graphical format. Once students learn the process of brainstorming and graphic organizers, they will be able to apply this strategy to the proverbial "back of the napkin" as they capture their ideas and inspiration.

Preparing a First Draft

The task of preparing a first draft is a painful process for all writers. Part of the problem that inexperienced writers face is that they cannot observe the cognitive process of playing with thoughts and trying to record them on paper or screen. The hardest part of writing is getting ideas from one's head to paper.

Today, most professionals compose all of their written work using a word processor. However, this is not necessarily true in all schools due to insufficient technology infrastructure and a lack of understanding about the efficacy research on writing. Table 6 provides a summary of the many kinds of technology-based writing tools that can be used to support student writers as they write.

Up to this point, researchers have been overly concerned about measuring the efficacy of specific writing tools with inadequate attention to the features that make various word processors similar or different. And, given the rate of change in the marketplace, it is probably unreasonable to believe that researchers will establish the unique contribution of any one product to a student's writing performance. As a result, it may be most appropriate to de-emphasize our interest in a specific tool and simply allow students to select from a menu of writing tools and help them explore the options that are available. The ultimate goal is not to ensure that diverse learners all use the same tool but rather regularly use a word processor to write.

Future Research

Whereas research has provided significant insights into how assistive and instructional technology can be used to enhance

Continued on page 40

TABLE 6. Instructional Technology Interventions for Writing a Draft

Instructional Challenge	Strategy	Technology Options
Students need a writing environment that is more flexible than drafting on paper.	Use a standard word processor to type the first draft of their paper or report.	Microsoft Word http://office.microsoft.com
		LibreOffice http://www.libreoffice.org/
	Use a specialized word processor that offers word prediction and audio support.	Co:Writer http://www.donjohnston.com
		WordQ http://www.goqsoftware.com
	Use a collaborative word processor to allow two or more students to co-author a paper or report.	Google Drive http://drive.google.com
	Use a word processor that offers a simplified interface to reduce the cognitive demands on the writer.	Max's Toolbox http://shop.fablevisionlearning.com/maxs-toolbox/
	Use a word processor that features both pictures and text to support emergent writers.	Clicker6 http://www.cricksoft.com
		PixWriter http://www.suncastletech.com
	Use dictation software/services to dictate the first draft in order to bypass problems in handwriting, poor keyboarding skills, or frustration in spelling correctly.	Dragon Naturally Speaking http://www.nuance.com/dragon
		iDictate http://www.idictate.com
		Speak-Write http://www.speak-write.com

the writing process, there is much more to be learned. Below are some important lines of scholarly inquiry for future research:

- New models of writing activities that focus on writing for digital communication, such as digital social studies (Bedard & Fuhrken, 2013) and scripts for animated movies *(http://goanimate4schools.com/)*, rather than word processing to print paper-based reports.
- Improved models of writing assessment (Olinghouse & Santangelo, 2010) that are more sensitive to students' ability to author complex texts.
- Understanding the multi-faceted interaction of multilingual students, writing tools, and writing outcomes (Graves, Valles, & Rueda, 2000; Silio & Berbetta, 2010) and the need for product design that includes AT or universal design features that support culturally and linguistically diverse students.

Conclusion

The ability to write clearly and effectively is considered one of the most important outcomes of education. However, students with LD struggle to achieve these outcomes because of the many ways in which their disability may have an impact on the many sub skills (i.e., handwriting, spelling, vocabulary, language) that must be simultaneously managed with meta-cognitive resources.

Parents and educators must be fervent in searching for technology-based writing tools that assist, scaffold, and support student writers in each phase of the writing process. One characteristic of the Information Age is that there are more tools available than ever before. While we know a great deal about instructional interventions concerning learning to write, much more remains to be discovered concerning the combination of writing technology tools that will allow struggling writers to find pleasure in the writing process such that they will willingly engage in the difficult, but rewarding process of thinking on paper and communicating through media.

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Mobile Instructional and Assistive Technology for Literacy

by David C. Winters and Elaine A. Cheesman

Since the introduction of the iPhone in 2007 and the iPad in 2010, the potential for widespread access to mobile technology is becoming a reality in homes, classrooms, and businesses throughout the world. Smartphones, tablets, and other mobile devices provide new avenues of access for everyone, whether or not a person has dyslexia or other literacy learning disabilities.

Mobile devices have several key characteristics that distinguish them from other instructional technology (IT) and assistive technology (AT) devices. First, they are portable and can be used in places where being connected by a cord would be unadvisable or where electricity is not easily accessible, such as when walking down the street. Second, they are lightweight and small enough to fit in a person's pocket or small personal bag. Third, their integrated functioning allows them to be used without additional components such as keyboards or monitors. Fourth, they have a means to transmit and sync data, often wirelessly. Fifth, most devices have a rapidly expanding number of applications (apps), the software that performs desired tasks. Finally, they allow easy and often automatic updating of apps and the operating system.

Both the hardware and applications of mobile devices fit well with the principles of Universal Design for Learning (UDL) and inclusion, especially in the ways that they help "make differences ordinary" (McLeskey & Waldron, 2007). As described in the introduction to this issue, UDL has three driving principles: multiple means of representation, multiple means of expression and action, and multiple means of engagement (CAST, 2011). Mobile devices, especially smartphones and tablets, uniquely provide options for all three of these guiding principles in a single device. In addition, because of the popularity and widespread acceptance of these smartphones and tablets, app use does not necessarily identify a person as having a disability, since people without disabilities often use the same apps to enhance their own functioning. Although mobile devices other than smartphones and tablets, such as the SmartPen (discussed below), might have a more limited scope, they too are valuable to persons with or without dyslexia or other literacy learning disabilities.

Mobile devices function well for both instructional and assistive technology. Mobile devices as instructional technology refers to using the devices while learning new concepts or practicing skills. When used as assistive technology, mobile devices allow a person to perform a function independently with which they would normally have difficulty.

Instructional Technology

When used as IT, mobile devices assist teachers and learners to expand reading and writing skills either as part of a) independent student practice or b) explicit teacher-led introductions. Although many different mobile devices are available, this discussion will be limited to iPads and their apps for teachers, educational therapists, and their students.

Apps for Independent Practice

iPads have the potential to increase student motivation, prolong focus, and build confidence (Bennett, 2012; McClanahan, Williams, Kennedy, & Tate, 2012). However, to improve student achievement using iPads, or any other medium, the activities must have a clear focus that is connected to student needs and one or more of the areas identified by research as essential for proficient reading, spelling, and writing—letter identification, phonemic awareness, phonics, fluency, vocabulary, and comprehension (National Institute of Child Health and Human Development, 2000). To engage learners for sustained, focused practice, an app must also have a professional design. These characteristics distinguish effective apps: a) accurate content validated by research; b) appropriate scaffolding to assist learners; c) timely feedback; d) professional sound and images to support learning; and e) intuitive and user-friendly interface with clear instructions (Ishizuka, 2011). All apps mentioned in this article meet these standards (see Table 1).

Word identification skill apps focus on the alphabet (identifying and writing letters), phonological awareness (noticing sounds in spoken language), phonics (mapping letters to sounds), and learning common sight words. For practicing the naming or writing of letters with no associated sounds, useful apps are *Handwriting Without Tears (http://wetdrytry.com)*, *Letter Find (http://rubberchickenapps.com)*, *Write-on Handwriting (www.writeonhandwriting.com)*, and *Cursive Writing* (Horizon Business). For linking sounds to letters, Preschool University's *(www.preschoolu.com) ABC Magic Phonics* and *ABC Magic 3 Line Match* are among the few apps that use voices of children and present *x* as /ks/ as in *fox* rather than /z/ as in *xylophone*. The latter also matches initial sounds to pictures to develop phonemic awareness. Other apps by Preschool University—*ABC Reading Magic and ABC Spelling Magic*—link sounds to letters explicitly and sequentially. *Fry Words* (Innovative Mobile Apps) presents sight words in groups organized by frequency, pronounces each word, and includes a game-like quiz for each level.

Interactive book apps include a) beginning readers that explicitly link letters to sounds and b) children's literature to strengthen language comprehension skills with mature vocabulary, complex sentence structures, and interesting content. *Starfall Learn to Read (www.starfall.com)* and *Bob Books Reading Magic (www.learningtouch.com)* are multi-book series in which children connect letters with sounds to spell words within carefully sequenced decodable stories. Children's literature book apps bring favorite stories to life with highlighted narration and clever animations. *The Cat in the Hat* and other Dr. Seuss titles *(www.oceanhousemedia.com)* and all titles by Loud Crow Interactive *(http://loudcrow.com/apps)* are a perfect introduction to "real" reading. Hearing text read

Continued on page 44

TABLE 1. Mobile Instructional and Assistive Technology Chart

Apps for Independent Practice: Handwriting		
Handwriting without Tears	$4.99	http://wetdrytry.com
Letter Find	$1.99	http://rubberchickenapps.com
Write-on Handwriting	$2.99	www.writeonhandwriting.com
Cursive Writing	Free	Horizon Business, Inc.
Apps for Independent Practice: Word Identification		
ABC Magic Phonics	Free	www.preschoolu.com
ABC Magic 3 Line Match	Free	www.preschoolu.com
ABC Reading Magic	Free - $0.99	www.preschoolu.com
ABC Spelling Magic	Free - $0.99	www.preschoolu.com
Fry Words	Free	Innovative Mobile Apps
Apps for Independent Practice: Interactive Book Apps		
Starfall Learn to Read	Free	www.starfall.com
Bob Books Reading Magic	$1.99 to $3.99	www.learningtouch.com
The Cat in the Hat (and others)	$3.99	www.oceanhousemedia.com
Loud Crow: Various titles	$0.99 to $4.99	http://loudcrow.com/apps
Apps for Independent Practice: Intermediate and Advanced Learners		
Vocabulary Spelling City	Free	www.spellingcity.com
A+ Spelling Test	Free	Innovative Mobile Apps
Poems by Heart	Free to $0.99	www.us.penguingroup.com
Find the Synonym	Free	www.freshapps.eu
4 Pics 1 Word	Free	iTunes Store, Google Play
Vocab Rootology	$2.99	www.prepinteractive.com
Apps for Explicit, Teacher-led Instruction		
Explain Everything	$2.99	www.explaineverything.com
Smart White Board HD	$1.99	Pad Read
Chalkboard	Free to $0.99	Presselite
Draw Everything! GLOW Note	Free to $1.99	Jae Kwang Lee
Doodle Buddy	Free	Pinger, Inc.
Sound Literacy	$25.00	http://soundliteracy.com
Flashcards	Free	www.flashcardapps.info
Dropbox	Free	www.dropbox.com
Mobile AT for Reading		
firefly	Free	www.kurzweiledu.com
Speak It!	$1.99	www.future-apps.net
Read to Kids	Free to $0.99	www.beesneststudios.com
Mobile AT for Spelling and Written Expression		
Dragon Dictation	Free	www.nuance.com
Inspiration Maps	$9.99	www.inspiration.com
Mobile AT for Note-taking		
SmartPen	$119.95 to $219.95	www.livescribe.com
Notability	$1.99	www.gingerlabs.com
Skitch	Free	www.evernote.com/skitch

aloud or reading with the narration (and being able to record your own voice in some apps) helps foster reading fluency.

Several useful options exist to provide instructional practice for intermediate and advanced learners. *Vocabulary Spelling City (www.spellingcity.com)* is a powerful app with a plethora of vocabulary, spelling, cursive handwriting, and alphabetizing activities available for pre-set or teacher-entered word lists. *A+ Spelling Test* (Innovative Mobile Apps) allows an adult to enter and pronounce custom lists for the student to spell. *Poems by Heart (www.us.penguingroup.com)* uses dramatic readings of classic poems to enhance memory and oral reading fluency. In *Find the Synonym (www.freshapps.eu)* the player combines the seven letters in each game to find the synonym or antonym before time runs out. *4 Pics 1 Word* challenges the player to use problem-solving skills, vocabulary, and spelling skills to guess a word that four images have in common. Fortunately, *http://4pics1word-answers.com* provides answers for downloading. *Vocab Rootology (www.prepinteractive.com)* provides 10 different ways to learn the most common prefixes, suffixes, Latin roots, and Greek combining forms.

Apps for Explicit, Teacher-Led Instruction

Research evidence supports direct, explicit instruction led by a knowledgeable teacher (Clark, Kirschner, & Sweller, 2012). For group instruction, an Apple VGA adaptor allows the iPad to connect easily to an LCD projector with a separate audio cable to project sound. This allows the teacher to project images from the iPad display to a screen or whiteboard. A VGA 2-port switcher will enable the teacher to switch the display seamlessly from iPad to computer.

Apps can replace many of the traditional tools of the trade in one device. Mirror apps (i.e., applications that turn your device into a mirror) are useful for teaching articulation as part of phonemic awareness. Drawing apps, when projected, can replace the traditional whiteboard or Smart Boards, allowing the user to write with a finger or stylus. These apps go beyond a traditional display of information, though. Many can record sound and import photos or PDF documents as a background. For example, the user can import examples of cursive letters to trace for handwriting, orally describe the strokes as he or she writes, and then save the finished recording that can be played back at any time. Using graphic organizer templates as background facilitates instruction in vocabulary, comprehension, and composition skills. *Explain Everything (www.explaineverything.com), Smart White Board HD* (Pad Read), *Chalkboard* (Presselite), *Draw Everything! GLOW Note* (Jae Kwang Lee) and *Doodle Buddy* (Pinger, Inc.) are three such drawing apps with good reviews and free or low cost versions.

Another valuable app, *Sound Literacy (http://soundliteracy.com),* replaces phoneme charts, Elkonin boxes, blank and tiles with vowel and consonant graphemes (*b, sh, ng, aw*), and cards for prefixes, suffixes, and roots. Flashcard apps allow one to create customized "decks" of cards. On one website *(www.flashcardapps.info)*, teachers can browse over 150 products with descriptions and reviews to find the product that meets their needs. Some apps allow the user to "shuffle" the decks or hide "mastered" cards. Other apps store sets of saved decks in a Dropbox *(www.dropbox.com)* account, a free cloud-sharing app, for use by multiple users.

Hundreds of new apps appear weekly; finding ones that are both engaging and accurate is a daunting task. One can find detailed reviews of specific apps as part of an occasional series featured in the online *IDA Examiner (www.interdys.org/examiner.htm)*.

Assistive Technology

When used as AT, mobile devices help a person with a function that he or she would normally find difficult or be unable to do at all. For people with dyslexia and other literacy learning disabilities, mobile devices can help with reading, spelling, written expression, and taking notes.

Mobile AT for Reading

Many individuals with dyslexia and other literacy learning disabilities struggle to decode print accurately and efficiently into meaningful language (Shaywitz, 2003). Therefore, many AT efforts have focused on developing hardware and software that converts text into speech, such as the computer-based Kurzweil 3000 *(www.kurzweiledu.com)*, a software program that takes scanned or entered text and reads it aloud. Although these programs have become technologically sophisticated, many of them require extra hardware, such as scanners, or use on a desktop or laptop computer, which limits their portability. With the introduction of smartphones and tablet computers, the process of converting text to speech has become much more accessible and portable.

For example, to complement the extensive Kurzweil 3000 program, the company recently released *firefly* for the iPad. While the app is free, users need a web license to one of the Kurzweil 3000 products for full use. The free app does have a number of sample materials, including several classic literary works. The app includes several voice choices for the reader as well as variable speed control and text highlighting. As long as the iPad has an Internet connection, a person can access any document in his or her Kurzweil Universal Library from anywhere.

If a person does not have access to the Kurzweil 3000 program, *Speak It! (www.future-apps.net)* is a low cost app available for the iPhone and iPad. The user chooses one of four voices to read text entered into the *Speak It!* window, either by typing or pasting from another document on the iPhone/iPad. The voices are clear and easy to understand. While the user controls are not as extensive as *firefly*, the app provides settings for text size, voice volume, and voice speed. Besides the four voice choices provided with the initial app, over 20 voices in several languages are available for in-app purchase. Interestingly, these voices not only read text in the native language but also English with an accent in that voice's language.

In addition to text-to-speech apps, the low-cost *Read to Kids (www.beesneststudios.com)* iPhone/iPad app allows a person to create an audio book using his or her own voice. Thus, a teacher or family member can record a book that is not otherwise available for a person with a literacy learning disability. This app also allows that person to follow the text in the actual book. Besides having a familiar voice do the reading, the app allows the audio book creator to add an auditory page turn indicator while recording. To allow people to try the app, the developer does offer a free version with a one-minute recording limit.

Mobile AT for Spelling and Written Expression

Although people with dyslexia and other literacy learning disabilities have difficulty with reading, they can also struggle with spelling and other aspects of written expression (Shaywitz, 2003). Computer-based applications such as those discussed in Edyburn's article in this issue provide important support to these writing difficulties; whereas, mobile devices primarily focus on text generation, including spelling and planning.

Word prediction was one of the first text generation strategies adopted by smartphones and tablets to help with both spelling and word choice. Word prediction software can guess what word the user is trying to type based on the first couple of letters. Depending on the phone or tablet operating system, the user may see a short list of possible words fitting the letters already typed and can choose the appropriate one. Some operating systems, such as on the iPhone, automatically insert a word after briefly showing it with an option for the user to keep the word as originally typed. Unfortunately, sometimes this autocorrect word prediction feature produces unintended and often comical changes. However, for a person who struggles with spelling, this feature can be very beneficial.

A second text generation strategy that aids both spelling and text generation fluency involves converting speech to text. *Dragon Dictation* is a free app for the iPhone and iPad with several elements of its full-featured desktop companion, *Dragon (www.nuance.com)*. Although the app requires an Internet connection, it is easy to use and quite accurate. After dictating the text, the user can use the device's pop-up keyboard to edit. The app gives several choices to save and share the text, including through email, Facebook, or Twitter, as well as by cutting or copying to paste into another program on the device. The app also allows the user to choose among numerous languages.

With the introduction of the iPhone 4S and iPad with Retina Display, Apple added a dictation feature to convert speech into text as part of the operating system. This feature allows an individual to dictate text rather than type as long as the device has an Internet connection. The user accesses it directly in an app such as email or messaging by tapping a microphone icon next to the space bar on the pop-up keyboard. Punctuation and some formatting commands such as capitalization can also be dictated. When finished dictating, the user taps the "Done" button, and the software converts the dictated speech into text that can then be edited with the regular keyboard. This conversion happens fairly rapidly, depending on the amount of text dictated, and has good accuracy.

Besides assisting with text generation, mobile devices can help writers with planning. *Inspiration Maps* is a low cost iPad companion app to the computer-based *Inspiration* concept mapping program *(www.inspiration.com)*. While users can integrate files between the mobile and computer-based versions, they can also use *Inspiration Maps* as a stand-alone app. The app includes several helpful templates in various content areas as well as the ability to create original maps. The app easily switches between diagram and outline views and includes several formatting and sharing options.

Mobile AT for Note-Taking

Although AT may help persons read and write more accurately and efficiently, many struggle with taking notes during classes or meetings, even persons with dyslexia and other literacy learning disabilities who have responded well to reading, spelling, and writing intervention (Mortimer & Crozier, 2006). Although many persons use laptops to take notes, others have begun to use mobile devices, especially those that allow a person to audio record while writing notes or drawing diagrams.

The *SmartPen (www.livescribe.com)* is a powerful note-taking aid, yet small enough to fit in a pocket or handbag. The pen includes a small infrared camera, microphone, processor, and memory for 200–800 hours of recording time. The pen records audio while the person takes notes on special microdot patterned paper. After finishing the session, the person can replay the audio that has been synchronized to the notes from the pen itself or on a computer or other mobile device. Since people often do not have time to listen to an entire session again, the listener can easily move the recording to a specific position by tapping the pen at the desired spot in the notes.

For individuals with an iPad, *Notability (www.gingerlabs.com)* is a low-cost, powerful note-taking app. Users can simply take notes by typing, writing, and drawing, or they can record audio while taking notes. In addition to many formatting options, the app allows the user to insert media such as pictures and webclips (i.e., shortcuts to specific websites). While the app synchronizes the audio to typed notes and media, allowing the user to easily jump to specific parts of the recording as with the *SmartPen*, it does not currently synchronize to handwritten notes. *Notability* has numerous ways to share notes, including printing, emailing, and storage in cloud-based services.

Besides mobile devices and apps that allow a user to both audio record and take notes, the built-in cameras found in smartphones and tablets provide another option. These cameras allow users to take photos of projected materials during lectures and presentations as well as document pages as they are passed around the group. Many of these cameras also allow video recording of a presentation, class, or meeting for later review. In addition, apps such as *Skitch (www.evernote.com/skitch)* allow a user to add notes, arrows, boxes, circles, highlighting, and other annotation marks to photos, PDFs, documents, and even screenshots.

Conclusion

Mobile devices have become an important resource for individuals with dyslexia and other literacy learning disabilities and those who teach and work with them. Whether used for literacy instruction or to assist a person with a difficult literacy function, mobile devices provide flexibility, portability, and easy-to-use strategies for all learners in a way that "makes differences ordinary" (McLeskey & Waldron, 2007).

Continued on page 46

 continued from page 45

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Global Perspectives

Update from the Middle East

by Charles Haynes, Ed.D., Professor, Graduate Department in Communication Sciences and Disorders, MGH Institute of Health Professions

Under the auspices of the Center for Child Evaluation and Teaching Global Partner in Kuwait (CCET), the Prince Salman Center for Disability Research (PSCDR, Riyadh) and King Abdulaziz University in Jeddah, IDA members Gad Elbeheri, John Everatt, Nadia Taibah, Pamela Hook, Abdessatar Mahfoudhi, and Charles Haynes have been engaged in two, complementary test development efforts in Kuwait and Saudi Arabia. Up to recently, diagnosticians trying to assess reading and language problems in Arabic have had few tests from which to choose and most of these instruments have lacked reliability and validity for the dialectal groups being tested. In both projects the focus is on building reliable, valid standardized tests for identifying dyslexia and related language learning disabilities in children who speak Saudi or Kuwaiti dialects of Arabic.

One project is a five-year multi-phase project funded by PSCDR and directed by Nadia Taibah (Principal Investigator) and Charles Haynes (Senior Project Advisor) of MGH Institute of Health Professions (MGH-IHP) in Boston. This project, now in its second year, involves development of standardized tests for grades K–6 in the areas of oral language (vocabulary, morphology, and semantics) and written language (reading and spelling). The team has also focused on devising batteries to assess phonological, orthographic, and non-orthographic visual processing. Pamela Hook, Professor Emerita from MGH-IHP, as well as Abdessatar Mahfoudhi of CCET have provided invaluable clinical and theoretical insights into the prototype and piloting phases.

The second project is a sixteen-month project involving standardization of measures of literacy (reading and writing), phonological processing and orthographic/morphemic awareness, as well as different aspects of memory functioning. Just funded by Prince Salman Center for Disability Research, the project is directed by John Everatt (University of Canterbury, NZ) and administered by Gad Elbeheri (Australian College of Kuwait) and Dr. Mosaad Abu Al Diyar, the Head of the Test Development Unit at CCET. This project will primarily focus on norming of school age tests for grades 2–5. While norms have already been developed for Kuwait, the goal is to provide additional test standardization for Saudi dialects. This is the second phase of a continuous project. During the first phase, a standardized test of phonological processing in Arabic was developed for both Kuwaiti and Saudi (Jeddah, specifically) norms. The second phase which has just started will focus on producing a standardized Test of Reading.

In June, this productive cooperation among international IDA colleagues from the two projects further extended to an Arabic Symposium at the International Association of Researchers in Learning Disabilities (IARLD) Conference in Boston. In a half-day session, research presentations by colleagues Gad Elbeheri, Abir Al Sharhan, and John Everatt were followed by comments from Discussant Charles Haynes.

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