

Dyslexia, Dysgraphia, OWL LD, and Dyscalculia

Lessons from Science and Teaching

Second Edition

by

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About the Authors

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Dr. Berninger received her Ph.D. in psychology at Johns Hopkins University and has had a career informed both by translation science (bridging basic research and application to practice) and interdisciplinary contributions to assessment, diagnosis, and treatment, including instruction. As a professor at the University of Washington, Dr. Berninger has been the principal investigator of research grants on typical language development and specific learning disabilities funded by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development and also the co-investigator of a research grant on math development and instruction funded by the U.S. Department of Education. This interdisciplinary research has been informed by Dr. Berninger's prior teaching experience (in urban, suburban, and rural settings in general and special education and at the elementary and secondary levels); training in clinical psychology and experience as a licensed psychologist (in assessment of developmental and learning disabilities); and ongoing consultation with schools, teachers, and parents for more than 30 years. Her current efforts focus on evidence-based, treatment-relevant differential diagnosis of specific learning disabilities and professional development for teachers and other professionals in schools and outside schools who influence school practices.

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Ms. Wolf received her M.Ed. in education at Seattle Pacific University and brings to this collaborative effort experience as a classroom teacher, a principal of an elementary school for children with dyslexia, Dean of Faculty for the Slingerland[®] Institute for Literacy, and an educational consultant providing professional development nationally and locally on structured language teaching. She has authored articles and books about dyslexia, creative activities for the classroom, and language-related guides for teachers. Ms. Wolf is a member of the Council of Advisors of the International Dyslexia Association (IDA), a past secretary and board member of IDA, the recipient of the John and Beth Slingerland Award from the Slingerland[®] Institute, the Beth Slingerland Award from the Washington State Branch of the International Dyslexia Association (WABIDA),



and the Outstanding Educator Award from the Renton School District. Through her professional experiences she has had the good fortune to hold the hands of teachers whose professional expertise and experience helped shape her own work as she in turn shared with them. Ms. Wolf is inspired by her ongoing work with the next generation of teachers. They stimulate her and motivate her to continue to develop materials that make teaching and learning exciting and fun. As she does, she reminds others that students with learning disabilities benefit from the collaboration of many professionals sharing with each other and learning from each other.



Use of Technology in Teaching

In the information age the interface between computer tools and student computer users is relevant to students with and without specific learning disabilities (SLDs). Although computer tools are often recommended for accommodations for students with SLDs, they can also be used for explicit instruction in oral and written language and math as discussed in Chapter 11.

TEACHING STUDENTS TO USE COMPUTERS

The computer is an invaluable tool for writing activities—it can be used to produce letters, detect and fix spelling errors, and generate and revise written texts. Several decades ago, Logan (1986) predicted that computer technology would enhance literacy. However, whether students with dysgraphia or with or without other SLDs benefit from use of computers in written expression may depend on whether they receive explicit, systematic instruction in keyboarding, spelling, and composing with the computer. The same graphomotor and orthographic coding processing skills that interfere with their learning to write with a pencil or pen could interfere with learning to use a keyboard to write (Berninger, 2007b). Therefore, multidisciplinary team assessments should evaluate the processes related to both handwriting and keyboarding in designing individually tailored instruction for a specific student. A recent study showed that students learned to form letters equally well by finger formation on a tablet and stylus (Tanimoto et al., 2015) but another dissertation study showed sizable individual differences in whether stylus or keyboard resulted in longer compositions; these individual differences varied

with writing task within the same student as well as across students. Moreover, elementary school students tend to hunt and peck on keyboards. Of concern is the lack of explicit instruction in touch typing in the upper elementary and middle school grades in many schools.

NEED FOR EXPLICIT HANDWRITING INSTRUCTION

For students with severe dysgraphia, a decision has to be made as to whether instruction should focus on just manuscript and cursive handwriting or on keyboarding to use in operating a computer for written assignments. Increasingly, research is pointing to the value of teaching both handwriting modes and keyboarding to students with and without SLDs (Alstad et al., 2015; Berninger, 2012, 2013). Research has shown that typically developing writers often use a mix of cursive and manuscript or revert to manuscript (Graham, Berninger, & Weintraub, 1998; Jones, 2004).

Even if students with dysgraphia struggle to write manuscript letters, they should be taught to read them. Most printed matter is displayed in manuscript, and other people use manuscript in their personal writing that students may need to be able to read. Likewise, even if students with dysgraphia struggle to write legible cursive letters, they should be taught to read cursive letters that others still use. If a decision is made that a student with dysgraphia should, as an accommodation, be allowed to use a computer for all written assignments, then explicit instruction in keyboarding should be provided. See Appendix 3B for resources on teaching touch typing. In addition, styluses and other writing tools are now available for writing on tablet computers.

Research shows that manuscript instruction transfers to improved word reading (Berninger et al., 1997), cursive instruction contributes to spelling (probably because connecting strokes link letters into word units; Alstad et al., 2015) in typically developing writers, and computers can teach students with dysgraphia to improve both their manuscript and cursive handwriting (Berninger, Nagy, Tanimoto, Thompson, & Abbott, 2015). Also, typically developing writers in elementary school write more words, write words faster, write more complex syntax, and express more ideas when writing by pen than by keyboard (Berninger et al., 2009; Hayes & Berninger, 2010). Manuscript and cursive contribute to the development of keyboarding skills from middle childhood to early adolescence in typically developing writers (Alstad et al., 2015). Thus, the keyboard is not a substitute for handwriting, and quality handwriting instruction and practice in composing with pencil or pen, as well as keyboard, are important for writers with and without writing disabilities.

NEED FOR EXPLICIT SPELLING INSTRUCTION

The need for explicit instruction in spelling continues even in the technology era with spell check, which flags possible spelling errors that can only be fixed if the computer user knows the correct spelling to select from the

menu of possibilities offered. Often, students with dysgraphia, dyslexia, and/or oral and written language learning disability (OWL LD) do not have grade-appropriate spelling skills. Appendix 4B provides evidence-based approaches for teaching spelling without a computer, which can improve the ability of students to proof and correct their spelling errors when using a technology tool to communicate in written language.

NEED FOR EXPLICIT WRITTEN COMPOSITION INSTRUCTION

Charles MacArthur has conducted long-standing programmatic research on the use of computers in teaching written composition (e.g., MacArthur, 2000, 2006, 2008, 2009; MacArthur, Ferretti, Okolo, & Cavalier, 2001). Computers have been shown to help both those who do and do not struggle with writing. As MacArthur's research has shown, computers can be used to teach strategies for planning, translating, reviewing, and revising a written composition. Spelling problems can be addressed during the revision of multiple drafts of compositions.

An important skill to learn beginning in middle childhood is to read source material and write about it, that is, to integrate reading and writing. Some source material is hard copy of traditional reading material but increasingly students are accessing posted entries online through search engines for use as source material. Students in middle school and high school benefit from systematic instruction in strategies for using both kinds of source material in school assignments, including the need to paraphrase and cite sources so as not to plagiarize.

USE OF COMPUTERS IN CONTENT AREAS OF THE CURRICULUM

An ongoing topic of interest in educational technology is whether computers deliver more effective instruction than human teachers. For example, see the research activities at the Assistive and Instructional Technology Lab in the College of Education at the University of Texas at Austin (<http://www.edb.utexas.edu/ATLab/index.php>). Other research has shown that using both visual and verbal information in designing and writing technology-supported instructional tools is more effective than verbal alone (Mayer, 2009). For a review of the research literature showing how computer games can enhance motivation for learning but not necessarily attention and engagement for language learning and evidence that computerized instruction aimed at all the multileveled, multimodal, multiple-language systems with human teacher monitoring can improve oral and written language skills and attention to and engagement in language learning for students with SLDs, see Berninger and colleagues (2014) and Tanimoto and colleagues (2015).

Another controversial topic has been use of computer tools in taking notes. Most of the research to date has been done with college students (e.g., Peverly, 2006; Peverly, Ramaswamy, Brown, Sumowski, Alidoost, & Garner, 2007) and

points to the conclusion that handwriting plays a very important role in note taking. More research on note-taking in developing students with and without SLDs, beginning in middle childhood, with a variety of letter production tools for varied purposes is needed. For students who have difficulty with the pace of class discussions or lectures, Smartpens and other audio recording devices may provide assistance. With these pens, students need only to replay the recorded lecture to add to the written notes what was not written during the oral lecture. This technology can remove the stress of missing out on important notes or having to catch up with the speaker.

The use of calculators has also been a controversial topic. The National Math Advisory Panel (2008) recommends that students first learn math facts and computational procedures using paper and pencil. Once those skills are mastered conceptually and procedurally, the use of calculators can be taught for problems that will require more complex calculations that build on the basic skills. The use of calculators allows these more complex calculations to be performed more quickly and efficiently by computer users who understand conceptually and procedurally the calculations involved.

Technology can also be used to create classroom economies. One of the reasons the business community has advocated for accountability of teachers is the perception that schools are not preparing students for the world of work. Therefore, some schools are preparing students for the future world of work by creating classroom economies to teach math, social studies about local and global economies, and science lessons related to science, technology, engineering, and mathematics (STEM) careers.

Technology tools have been developed to guide classroom teachers in designing and implementing classroom economies as part of the instructional program. For example, Talbot Hill's MicroSociety Program simulates a functioning community, with student-run businesses and services. Together, students run businesses, banks, a marketplace, and a government with branches for taxation, licensing, and dispute resolution. Each student earns "cool cash," which can be used to purchase student-made goods at the marketplace. This model is based on the MicroSociety program (<http://www.microsociety.org>) used in hundreds of schools nationwide, which is made available and supported by a nonprofit organization.

Students have a chance to practice everything they learn in the classroom during their MicroSociety activities. Reading, math, language, social studies, and technology become practical tools rather than abstract concepts. Running a business teaches the consequences of behavior: students learn they must work in order to be paid, cooperate in order to get a job done, and plan ahead. From the student-written laws to the mediation and court process for enforcing the laws, students learn that they have the power to make a difference in their world. For further information about how the Renton Schools implemented Talbot Hill's MicroSociety Program, contact coordinator Sally Boni at sally.boni@rentonschools.us.

USE OF COMPUTERS FOR BOTH ACCOMMODATION AND EXPLICIT INSTRUCTION

Computer tools can be used for accommodations as well as explicit instruction for students with SLDs. Assistive technology (AT; Bryant, 2015; Bryant & Seay, 1998; Bryant, Seay, & Bryant, 1999; Mace, 2010) is helpful especially during middle school, high school, and postsecondary education (e.g., Bryant, Bryant, & Rieth, 2002). Simulations of how AT devices can be used across the lifespan and in various contexts for students with and without SLDs have been designed with Universal Design for Learning guidelines and principles (CAST, 2010) in mind; see the work of Brian and Diane Bryant (e.g., Bryant & Bryant, 2012; Bryant, Bryant, & Rieth, 2002; Bryant & Seay, 1998; Bryant et al., 1999; Bryant, Seok, Ok, & Bryant, 2012). They advise that instructional technology tools can be used to enhance the education of students with and without SLDs, but it is always important to find the best match between the technology and the learner. One size does not fit all when it comes to AT tools or apps.

Examples of technology tools that can be used for accommodations and assistance in instruction (Julnes & Brown, 1993) include the following:

- *Scanning*: Desktop scanners or other technology can be used to scan grade-appropriate text into text-to-speech software programs, which can then read the text back to students who cannot read and comprehend the texts well enough on their own. This computer application gives students with dyslexia or OWL LD access to grade-appropriate content, despite reading problems, for completing writing activities.
- *Dictation and speech recognition*: Another computer tool that has proven helpful to some students is dictation and speech recognition technology (e.g., MacArthur & Cavalier, 2004) for creating written assignments. Students can orally express their ideas, bypassing writing problems due to handwriting as in dysgraphia or spelling as in dyslexia. The technology translates the oral language into written language to assist in preparing a written assignment.

Best practices for the use of technology tools include that the accommodation should be linked to the problem it is addressing. For example, if the student has difficulty with accuracy or rate of reading, then computerized tools are recommended that allow teachers to scan any text material into the computer program, which then regulates the reading rate and highlights each word as it is spoken. If the student has difficulty with legible handwriting, then the use of a keyboard may be helpful. However, if the difficulty is with spelling, spell check, which flags typographical errors, may not be an appropriate accommodation. Unless a student has the ability to recognize the correct spelling from a menu of options, the spell checker alone will not be adequate compensation for lack of spelling skills. As Charles MacArthur on the Advisory Panel for Berninger (2015) pointed out, the goal should be to teach students to use spell checkers intelligently. They need to know that spell checkers will not find all

errors, and students still need to proofread their work. Students also need to know how to select correct replacements once errors are found. MacArthur's cited research shows it is possible to teach these spelling skills.

No matter how computers are used for accommodation, explicit instruction in the skill area(s) with which a student has difficulty should continue to be provided. Both reading and writing skills, even if they are behind the typical developmental stepping stone schedule (see Chapters 4, 5, and 6 in Berninger, 2015) trajectory, can still be remediated in students without developmental disabilities during early childhood, middle childhood, and adolescence.

More research is needed on which technology tools may be most beneficial for students in general, as well as for accommodation of students with SLDs. For example, tracing with the index finger on a tablet involves forming a letter without a pencil grip, whereas writing with a stylus on a tablet involves forming a letter with a pencil grip and may help in early childhood. Also, more research is needed on how and when to integrate technology tools with instruction so they are not used only outside school for games, homework, and social networking.

USE OF TECHNOLOGY TOOLS AT SCHOOL AND OUTSIDE SCHOOL

Throughout schooling, all students should be taught safety precautions for the use of cell phones, headphones, and texting while crossing streets or walking anywhere there is car and bicycle traffic. When users are attending to the audio and visual stimuli or manual activity (while texting), they do not have sufficient attention capacity and resources to monitor the changing events in the external environment. Just as schools have traditionally provided safety education on paying attention to the color of signals in traffic lights for go, caution, and stop, safety issues regarding current technology also need to be taught. Beginning in early childhood, students need to learn to pay attention not only to what they hear through headphones or text messages on their cell phone screens, but also to drivers, vehicles, and other pedestrians when crossing the street.

Students benefit from discussion of socially appropriate and inappropriate use of technology. They need to learn what is and is not appropriate to "write" to others electronically. Appropriate and inappropriate content, tone, and language used should be addressed. Educators should spend more time teaching etiquette for online engagement, such as for opinion writing in blogs, discussion posts, and comment sections. These lessons can also be integrated into writing genre instruction at the secondary level (e.g., how to write business letters and e-mails).

One of the roadblocks to the increased integration of technology into the daily instructional program is the fear that students will use the Internet for bullying or be victims of predators who use it to contact minors. Schools face legal risks if such adverse events occur when students are using a computer

with Internet access during class time. One way to prevent such events is to use only technology tools that do not require Internet or web access is turned off. Students may also benefit from ongoing instruction in appropriate and inappropriate ways of using the Internet for finding information and evaluating its authenticity.

Importantly, overuse of technology devices can undermine development of oral language including vocabulary skills for the social functions and use of language. The increasing use of handheld electronic devices may interfere with a student's development of making eye contact with the teacher and other students, experience in learning to read body language, and development of appropriate social interaction. Addiction to technology is becoming an increasing societal problem. Signs of addiction to texting, social media, or cell phones are that the technology user cannot disengage from technology, which in turn impairs the quality of functioning in life. One mother expressed how pleased she was when she set limits and did not allow her son to use his phone all the time; he started to focus more on school work and experienced greater academic success than in the past.