Technology to Support Writing by Students with Learning and Academic Disabilities:

Recent Research Trends and Findings

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Abstract: The trends and findings from a descriptive analysis of 25 years of research studies examining the effectiveness of technology to support the compositional writing of students with learning and academic disabilities are presented. A corpus of 85 applied research studies of writing technology effectiveness was identified from among 249 items in the scholarly literature. The use of technologies to support each of the components of the writing process is reported in terms of the research designs used, the writing processes supported, and the historical trends in research publication. The research designs represented in the research base suggests that, overall, there is a developed program of research; however, this does not hold for the individual writing process areas (planning, transcription, editing, and revising). Among the four process areas, the largest number of studies is of technologies to support transcription with revising the next most frequent and few studies of planning/organization and editing. Comparison of the historical trends in research to trends in technology development revealed that little new research investigating basic digital writing support tools, as used by students with learning and academic disabilities, has appeared in the last 10 years despite the growth and development of technology. Across the total corpus of applied research studies, basic evidence-based practice criteria related to number of studies and number of participants was not met in the areas of planning and organization, editing, and revising technologies. Applied research studies of the effectiveness of transcription tools nearly meet the criteria for number of studies and number of participants, and nearly enough to warrant further analysis of study quality and effect sizes. Taken together these findings underscore the critical need for further research on the effectiveness of contemporary technologies to support compositional writing.

Keywords: Technology, Composition, Writing, Research trends, Learning disabilities, Disabilities

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Writing matters. Along with reading comprehension, writing proficiency predicts academic success (Graham & Perin, 2007), develops higher-order thinking skills (National Writing Project & Nagin, 2006), is an essential 'threshold skill' for hiring and promotion (National Commission on Writing, 2004), and is a basic requirement for participation in civic life and a global economy (Graham & Perin;

National Commission on Writing, 2003). However, writing achievement is not where it is expected to be and not where it needs to be. State governments report that, despite the high level of educational attainment of state employees compared with that of the general public, approximately 30% of professional employees fail to meet state writing expectations (National Commission on Writing, 2006). Nearly one-third of students who intend to enter higher education have not attained the readiness benchmarks for college-level English composition courses (ACT, 2005). According to the National Assessment of Educational Progress (NAEP; Persky, Daane, & Ying, 2002), many students (51%–58%) are at a basic level of writing, which is below the desired *proficient* level. Those 16%–22% of students below even the basic level of writing reported by the NAEP are *struggling writers*, called *low-achieving writers* by Graham and Perin (2007). They include students identified as having learning disabilities (LD) as well as others with academic and learning difficulties whose writing skills are not adequate to meet classroom demands (Graham & Perin). The findings of the NAEP for 'students with disabilities,' which here refers to all students with disabilities who completed the NAEP writing assessment, are sobering. In 2007, students with disabilities received an average scale score of 119 at the 8th grade and 118 at the 12th-grade levels as compared to 160 and 156 (max = 300). From 1998 to 2007, the gap between students with and without disabilities has remained about 40 points with only a 9% increase in scores. The 2007 results translate to poor levels of writing attainment; 45% of students with disabilities are below the basic level of proficiency (8% without disabilities) while 49% are at only a basic level (56% without disabilities) and only 6% are at the proficient level (33% without disabilities; *U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1998, 2002 and 2007 Writing Assessment*, n.d). More than six times as many students with disabilities performed below the basic level than did their typical peers.

If writing matters, then writing instruction needs to improve (Graham & Perin, 2007; National Commission on Writing, 2006; National Writing Project & Nagin, 2006). The research-based models and methods for teaching good writing are known (National Commission on Writing; National Writing Project & Nagin). Good writers use three primary, recursive processes: (a) planning (generating ideas, setting goals, and organizing, referred to in this paper as "planning"); (b) translating (turning plans into written language, referred to here as "transcription"); and (c) reviewing (herein referred to as "editing and revising") (National Writing Project & Nagin). These processes are represented in instruction as *writing strategies* wherein students are provided (a) models; (b) some direct instruction; (c) some kind of scaffolding (an explicit framework or sequence of steps) that gives them an organizational scheme; and (d) guidelines for using inquiry strategies (e.g., imagining a situation from a perspective different than one's own, comparing and contrasting cases, explaining how evidence supports a claim) (National Writing Project & Nagin).

Despite agreement about what constitutes good writing instruction, effective strategies are not widely used (National Commission on Writing, 2003, 2006). To bring about reform in writing instruction, the National Commission on Writing (2003) noted four challenges to education professionals: (a) increase the amount of time that students spend writing, (b) improve the assessment of writing, (c) apply emerging writing technologies, and (d) provide professional development for all teachers.

Technology to Support Writing

Among national organizations considering writing outcomes, there is widespread acceptance that writing has moved from a paper and pen activity to one that is technology-driven. Throughout this report, the term 'technology' will refer to digital technology. Technologies are recognized as having potential both to support writing and the teaching of writing (National Commission on Writing, 2003; National Writing Project & Nagin, 2006) and to represent new venues for writing itself (National Council of Teachers of English, 2004). Three approaches to technology have emerged from this discussion: *technology-supported writing, technology-enabled writing,* and *multimedia writing.*

Technology-supported writing can advance all phases of writing—planning, transcribing, and editing and revising using tools, which include, but are not limited to, the word processor. But technology also enables writing in new ways. Technology provides new sources for and means of obtaining information (e.g., the Internet, search engines) and enables sharing, editing, and collaboration among writers, teachers, and peers. The ability to work from remote locations permits students to gauge the quality of their writing and their level of skill against those of peers elsewhere (National Commission on Writing, 2003, 2006; National Writing Project & Nagin, 2006). Finally, technology transforms writing by introducing new electronic genres and multimedia forms. In these new genres and forms, composing involves a combination of media, including print, still images, video, and sound (National Council of Teachers of English, 2004). The movement from writing as a pen-and-pencil enterprise to one including dramatically different forms of creation, expression and communication is explored in *Because Digital Writing Matters* (National Writing Project & DeVoss, Eidman-Aadahl, & Hicks, 2010). Digital writing is defined as "compositions created with, and oftentimes for reading or viewing on a computer or other device that is connected to the Internet" (National Writing Project & DeVoss et al., p. 7). The tools used for composing are not limited to the word processor. They include many digital forms of encoding (recording) information including scanners, digital cameras, voice recorders. Networked connectivity permits writers to "draw from myriad sources, use a range of media, craft various types of communication representing a range of tools and genres, and distribute that work almost instantaneously and sometimes globally" (National Writing Project & DeVoss et al., p. 7).

But, where are schools and students with disabilities in all of this? The assessment of writing in statewide high stakes testing may be both a driver and an inhibitor of writing instruction and assessments in schools. While proponents of the new forms of digital writing decry the old 'scripted genres' as being limiting to students development of 21st century writing skills (National Writing Project & DeVoss et al. 2010), assessments such as the National Assessment of Educational Progress (NAEP) use traditional genres or purposes for writing (e.g., narrative, informative, persuasive) that have defined structures and requirements for the compositions. In addition, the use of the word processor as a tool to assess writing is not even standard among states (Russell & Abrams, 2004; Russell, Goldberg, & O'Connor, 2003). While empirical research suggests that digital natives perform better when using word processors (Russell, 1999; Russell & Haney, 1997; Russell & Plati, 2001, 2002), surveys indicate that non-use of word processing on statewide assessments may be influencing teachers to avoid their use and emphasize paper and pencil writing to prepare students for testing (Russell & Abrams). While the new tools, media, and forms may be the now-and-future, the old media and forms

continue to be the now-and-now. For students with disabilities to make advances in writing performance on measures like the NAEP, there needs to be a critical examination of the tools and technologies that may provide compensatory benefit, i.e., that assist these students to overcome barriers created by a range of persistent cognitive and physical factors (Peterson-Karlan & Parette, 2008).

Writing Problems of Students with Learning and Academic Disabilities

Students with learning and academic disabilities demonstrate an impressive array of problems in writing. Based upon a corpus of 41 research studies, Newcomer & Barenbaum (1991) produced the seminal review of the written composing abilities of children with learning disabilities covering the decade of 1980-1990. This summary served as the impetus for much of the subsequent research in this area--research that either more fully detailed the characteristics outlined by Newcomer and Barenbaum or that attempted to remediate the problems identified by these authors through a variety of teaching and/or technological approaches. Relative to typically developing peers, students with learning disabilities have decreased skills that do not improve over time or years in school (under typical conditions of instruction). In comparison to typical peers, students with learning disabilities (a) make more *mechanical* errors, including spelling, punctuation, and capitalization (fourth grade through college), with spelling errors the most pronounced; (b) make more subject/predicate agreement (*syntax*) errors; (c) are less *fluent* (i.e., use fewer words, particularly those with seven letters; produce fewer sentences, and use less variety of words); and (d) do not exhibit an increase in fluency with age (maturity).

Overall, in *narrative writing*, students with learning disabilities reflect a paucity of ideas that prevents them from embellishing their narratives and, as a result, produce qualitatively perfunctory stories that may not meet the minimal requirements for a story. Problems with cohesiveness suggest an inability to retain an overview of purpose or direction of the composition (lack a story 'plan'), instead writing any thought that occurs -- indiscriminately and often inappropriately. Data suggests that students with learning disabilities have only cursory knowledge of what a story is and do not know or remember how to expand a composition beyond this level, lacking the composing skills to identify organization problems during revision (Newcomer & Brenbaum, 1991).

Overall, in *expository writing*, students with learning disabilities produce compositions exhibiting mechanical errors, irrelevancies, redundancies, early termination, lack of coherence and organization. The type of text structure of the composition differentially affects the type and extent of errors. Sequencing appears to be the easiest text structure and compare/contrast the most difficult. The problems exhibited by students with learning disabilities were not only more frequent compared to typically achieving peers at grade level, but were significantly worse than underachieving students matched for reading level and IQ. Metacognitive research in this corpus focused upon expository, rather than narrative, composing and compositions. Specific analysis of the use of metacognitive knowledge and cognitive strategies while writing reveals that students with learning disabilities compared to typical peers demonstrate (a) less knowledge of steps in the writing process, including the relevance of planning; (b) less knowledge of the structures of various expository texts; (c) fewer procedures for generating, selecting, and integrating information from multiple sources; and (d) fewer strategies for organizing and presenting expository ideas, including modeled strategies.

There is a long history to the suggestion that technology can be particularly advantageous for students with learning and academic disabilities in remediating or compensating for these problems. Word processors, word prediction, spell checkers, text-to-speech, and organization tools have all been extensively discussed as helping or having potential to help students with disabilities to engage in the many levels of cognition required to produce coherent, organized, audience-aware, and conventionally accurate compositions (e.g., Forgrave, 2002; Hunt-Berg & Rankin, 1994; MacArthur, 2000, 2009a, 2009b; Montgomery & Marks, 2006; Sitko, Laine, & Sitko, 2005; Zhao, 2007). However, only recently has there been systematic examination of the existing evidence base using historical and meta-analytic synthesis techniques that might support such claims (Cochran-Smith, 1991; Goldberg, Russell & Cook, 2003; Graham & Perrin, 2007, Okolo & Bouck, 2007; Peterson-Karlan & Parette, 2007b; Rogers & Graham, 2008). Based upon a comprehensive compilation and examination of the literature related to the use of technology to support writing by students with learning and academic disabilities (Peterson-Karlan 2011; Peterson-Karlan & Parette, 2007b), this paper reports on the characteristics of this literature base, trends in research over time, and implications for conclusions regarding the effectiveness of technology as related to specific components of the writing process. The overall purpose is to determine what is known from empirical research regarding technologies to support writing and whether technology to support writing is an evidence-based practice.

Compiling and Synthesizing the Research Literature

To identify published articles related to technology that supports writing by students with learning and academic disabilities, multiple searches were completed using the Academic Search Premier, ERIC-OVID, and PsycINFO electronic databases (search range 1994-2010). Each search was refined with a three-phase process whereby initial search terms were modified, with each subsequent search using keyword and title descriptors identified from the previous search. Where available, text searches of these terms were also completed. Hand searches were conducted of 15 journals known to publish articles on the topic (search range 2003-2005); subsequently, "hand searches" of the electronic article listings of a number of the most cited journals using the databases were conducted (search range 2005-2010). For each article identified, ancestor searches of the references cited in the article were also completed. Ancestor searches were useful in identifying literature from the 1985-1994 range of years. If authors appeared to have multiple publications in the search area of interest or if certain authors were cited frequently in the identified literature, additional author searches were conducted, using the three databases to identify any appropriate systematic lines of research. Complete details of the search methodology are available elsewhere (Peterson-Karlan, 2011).

For each item of literature, a complete APA-formatted reference was created in an electronic software database (*Endnote*®). To synthesize the findings, each item of literature was coded in the reference database (*Endnote*®) using the descriptor terms reported below in the results section; in general the categories included type of article, type of research design, writing process investigated or discussed, and specific technology tool. Based on the writing process and technology, tables of findings were also created for all research studies. Complete details and the table of findings are available elsewhere (Peterson-Karlan, 2011). The descriptors and tables of findings were used to prepare the summaries and general findings reported herein.

Descriptive research synthesis using these approaches is useful in (a) determining the size of the evidence base, (b) identifying trends in research, and (c) identifying the design characteristics of the evidence base. Descriptive research synthesis also is useful in identifying relevant variables investigated across the evidence base related to both the process and products of writing; in determining what we know and what we need to know; in helping to interpret "what we know" regarding the chronological development of the writing technology; and in identifying limits to our conclusions in light of the extent of the evidence base, the research designs used, and the development of technology over time. Descriptive research syntheses can provide the information needed to conduct meta-analyses of the evidence base to determine effect sizes, which yield quantitative measures of the effectiveness of technology to support writing across the evidence base (see e.g., Goldberg et al., 2003; Graham & Perin, 2007; Rogers & Graham, 2008).

Overall Characteristics and Trends in the Evidence Base

There were 249 items of literature in the final database (see Figure 1). Of these, 33.7% (*N*=85; see Appendix A for a listing of these studies by writing process) were applied research studies of writing technologies, while 39.3% (*N*=99) were categorized as background or basic research on the technologies themselves. Such research includes studies of writing technology by typically developing students only and studies of the functionality of the technology itself, e.g., the accuracy of spellchecker accuracy in detecting and suggesting replacements for words misspelled by students with learning and academic disabilities. The remainder of the literature base consisted of (a) articles, books and chapters that discuss the process of writing and/or approaches to using technology to support writing or describe the problems exhibited by students with learning and academic disabilities when writing (19%, *N*=48); (b) national reports on the status of writing (3.6%, *N*=9); and (c) meta-analytic research syntheses of effectiveness of instructional approaches to improving writing or technology to support writing with typical students and/or students with disabilities (4.4%, *N*=11).

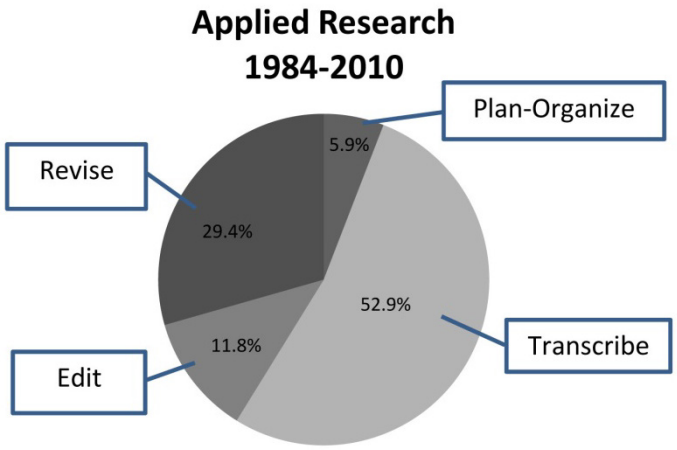

Figure 1. The final literature collection.

Research Designs Used to Examine Technology Effectiveness

The issues related to the need for, difficulty in establishing, and characteristics of standards or criteria for an evidence-based practice for special education have been addressed extensively elsewhere (Odom, Brantlinger, Gersten, Horner, Thompson, & Harris, 2005; Peterson-Karlan & Parette, 2007a). Of specific interest in this discussion is the contribution of research design to the emergence of claims of effectiveness of a practice. Within the larger discussion, a point of agreement is that there are three central research questions addressed in educational and special education research: (a) What is happening (description)? (b) Is there a systematic effect (cause)? and (c) Why or how is it happening (process or mechanism)?

There is further agreement that each type of question is both scientific and requires different methodology (Odom et al., 2005). Four different research design methodologies have been identified as appropriate for addressing these questions: (a) experimental group; (b) correlational; (c) single-subject; and (d) qualitative (Odom et al.; Peterson-Karlan & Parette, 2007a). Experimental group designs include both 'random assignment experiments,' more commonly referred to as the *randomized controlled trial* (RCT), and quasi-experimental designs, which involve use of subjects as their own controls (e.g., the repeated measures design). While RCT designs have been cited as the highest standard for research on the effectiveness of a treatment or intervention practice (Odom et al.; U. S. Department of Education, 2003), other designs also permit analysis of competing explanations for the effectiveness of a practice (Peterson-Karlan & Parette).

To understand the contribution of various research methods or designs in determining the effectiveness of technology to support compositional writing by students with learning and academic disabilities, it may best to view the development of the evidence base as an 'emerging program of research.' Levin, O'Donnell and Kratochill (as cited in Odom et al., 2005) have proposed four stages of research within which certain designs are most appropriate. In Stage 1, preliminary ideas, hypotheses, and observations are obtained and explored using case studies and qualitative and correlational designs. In Stage 2, controlled laboratory experiments or classroom-based systematic observations and experiments are conducted using qualitative, single-subject, quasi-experimental, and experimental (RCT) designs to explore the questions of cause, process, or mechanism. In Stage 3, results of the prior research are used to design well-documented large-scale studies to determine the effectiveness of a practice or intervention. The RCT design is considered to be the 'gold standard' for such research, although an argument for the appropriateness of large scale single subject design studies has also been made (Horner et al., 2005; Odom et al.). The final stage of the research process determines those factors that lead to adaption of effective practices in typical school systems under naturally occurring conditions and requires the application of a number of research methods.

The foregoing discussion suggests that the issue is not excluding studies from this review based on some judgment as to the 'value' of the design, but rather, that the various designs provide perspective on the development of a program of research on technology to support writing. In general, case studies are indicative of an early stage of exploration while small-*N* single-subject studies reflect an emergence of early 'scientific knowledge.' Large-*N* single-subject, quasi-experimental, and 'true' experimental design studies represent a more rigorous knowledge base capable of substantially eliminating plausible competing explanations for obtained results, and present

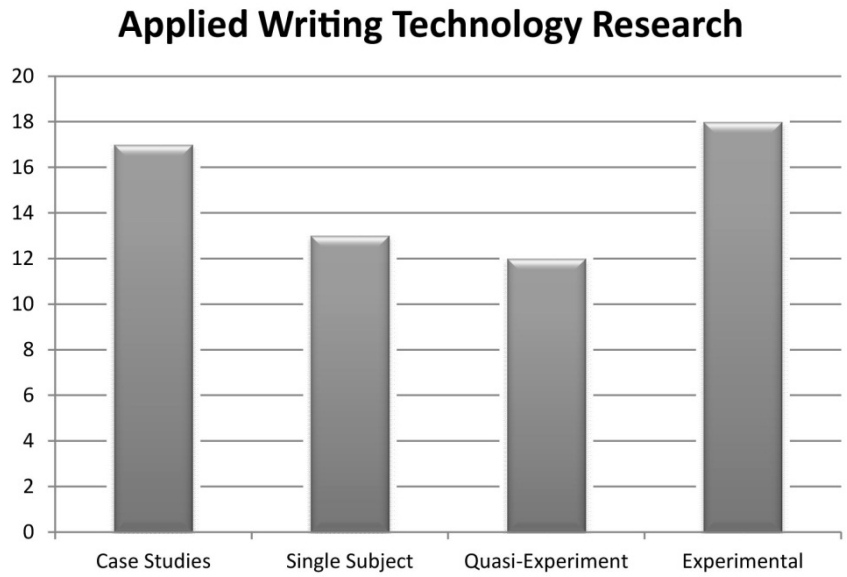

Figure 2. Research designs used.

'strong evidence' of effectiveness (Peterson-Karlan & Parette, 2007a; U. S. Department of Education, 2003).

Within the group of applied research studies examining the effects of technology to support compositional writing by students with learning and academic disabilities (*N*=85), there is a fairly equal representation of empirical research designs (See Figure 2) with experimental (use of control groups) the most frequent design (*N*=18), and both quasi-experimental (e.g., within subjects repeated measure) and single-subject designs (e.g., multiple baseline across participants) being about equally represented (*N*=12 and 13 respectively.) Case studies represent only 20% of the overall direct evidence base (*N*=17). These findings suggest that the evidence-base does represent a developed program of research overall; however, as discussed next, this is not equally true for research on technology to support each aspect of the writing process.

Within the total group of applied research studies, the most frequent writing process examined has been transcription (53%, *N*=45) with nearly 1,400 students with learning and academic disabilities and typical peers included in studies examining the effectiveness of technology to support transcription (see Figure 3). Studies of the use of technology to support the revision process are next most frequent among all applied research studies (29.4%, *N*=25), but including a much smaller number of students with and without learning and academic disabilities (*N*=115). Much less frequent in the evidence base are studies of the use of technology to support editing (11.8%, *N*=10) and the planning and organizing processes (5.9%, *N*=5). While transcription is an important process, representing the ability to generate text that is both legible and conventionally accurate (spelling, punctuation, grammar), planning and organization are perhaps more important to producing compositions that are coherent, organized, understandable, and interesting to the reader. Despite the fact that technologies to support for the critical planning and organization processes in compositional writing exist (e.g, *Draft:Builder*®; *Inspiration*®), lack of an evidence base for students with learning and academic

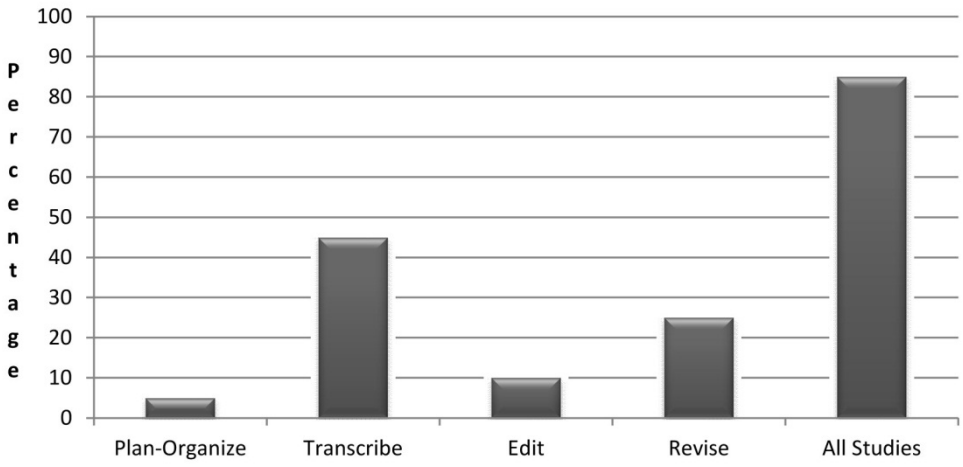

Figure 3. Research studies by writing process.

disabilities is a serious deficiency of the research field.

Figure 4 shows the distribution of research designs used in the studies of technologies to support compositional writing by students with learning and academic disabilities across the four writing processes. There are few planning research studies (*N*=5) with those including mostly quasi-experimental (*N*=4) and experimental (*N*=1) designs. Transcription research studies include cases studies (32%, *N*=12) single-subject design studies (26%, *N*=10), quasi-experimental designs (10.5%, *N*=4), and experimental designs (32%, *N*=12). Editing research studies (*N*=10) include an equal proportion of case studies (*N*=3), quasi-experimental (*N*=3), and experimental (*N*=3) design studies with only one single-subject design study. Revising research studies (*N*=7) include an equal proportion of case studies (*N*=2), single subject (*N*=2), and experimental (*N*=2) design studies with only one quasi-experimental design study. These numbers indicate that the transcription, editing and revising research base demonstrates a trend toward increasing maturity in the scope and purpose of the research but little volume on which meta-analytic techniques can be applied to render quantitative conclusions about the effect of technology on the writing process for students with learning and academic disabilities. The extent of the research base needed for this type of analysis will be addressed in more detail below.

Historical Trends in Technology Research

The research base compiled here extends over a period of 26 years (1984-2010). During this time, many technological advances were made in the underlying operating systems and application technologies. Any conclusions about the effectiveness of the technology or the generalizability of the findings in supporting compositional writing by students with learning and academic disabilities must be viewed relative to the development of the technology itself over time. Thus, it is necessary to examine the historical trends in development and publication of the research base. Figure 5 presents the overall historical trends in applied research on technology to support compositional writing by these students. Examination of the frequency of applied research studies yields a disturbing

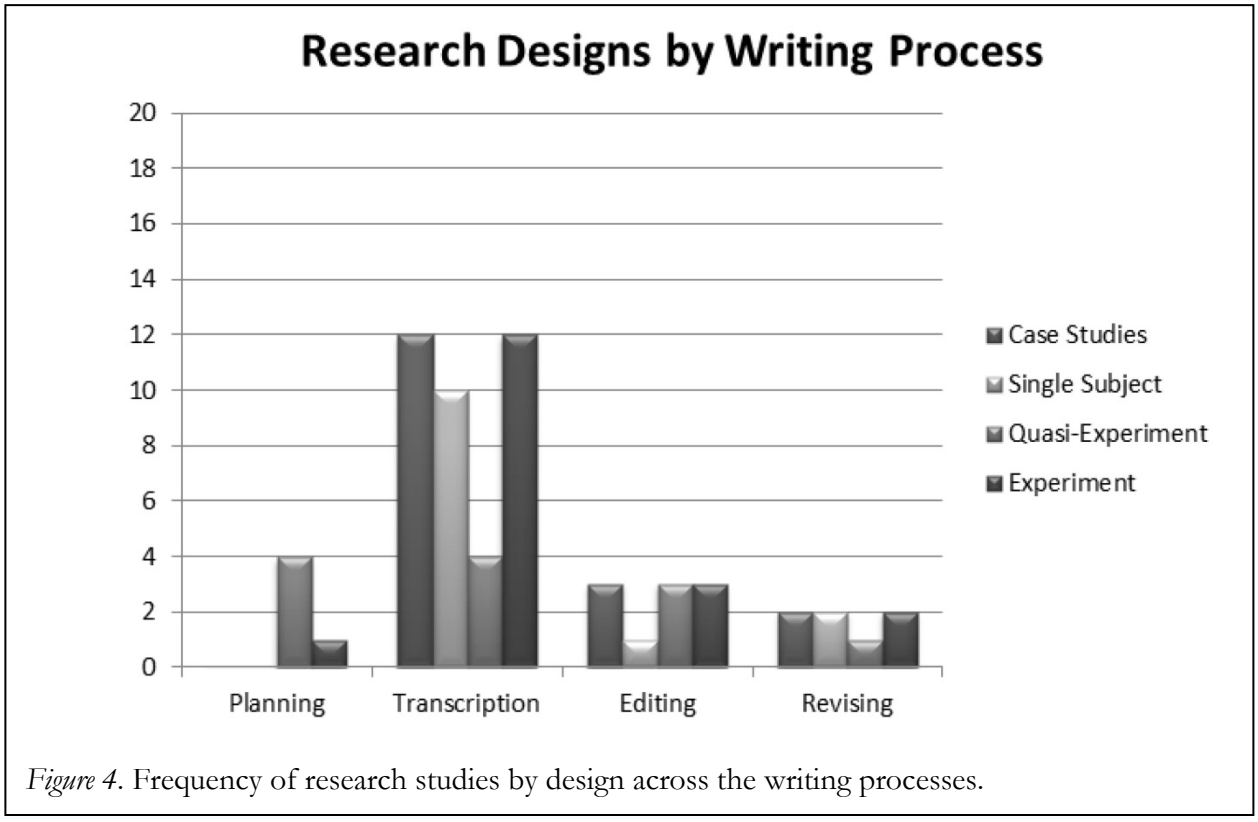

Figure 4. Frequency of research studies by design across the writing processes.

conclusion; as technology availability has exploded in the last 10 years (Parette, Peterson-Karlan, & Wojcik, 2005), the frequency of applied research investigating the use of technology to support compositional writing by student with learning and academic disabilities across all four writing processes has declined dramatically. In the last five years (2006-2010), only five studies were located, with only 13 in the previous five years (2001-2005). That is less than two studies per year! In contrast, in the 16-year period of 1984-2000, there were 65 such studies published in peer-reviewed journals, representing 4.3 published studies per year. It would be erroneous to conclude that perhaps we had acquired all the information, or 'answers,' that we needed in that first 15-year period.

Examination of the research with students with learning and academic disabilities using technology to support transcription provides evidence that such a conclusion is incorrect (see Figure 6). The peak in frequency of studies came in the 5-year period of 1984-1990 that preceded introduction of Microsoft® *Word* for Windows®, the first Microsoft® word processor with a graphical user interface (GUI). In the next five years, there was 40% less research examining the use of the 'new' GUI word processors to support the transcription of students with learning and academic disabilities. The frequency of such research has continued to decline despite the improvements to and enhanced features of the GUI word processor. It would be difficult to argue that the findings for the effectiveness of word processors in improving aspects of compositional writing would be equivalent for non-GUI and GUI-based word processors. Graphical, menu driven interfaces support recognition of features, e.g. spellcheck), rather than recall of command prompts (e.g. c:\\print), and *What-You-See-is-What-You-Get* (WSYWIG) views of the final written product. Similarly, interpretation of applied research examining the effectiveness of speech recognition (speech-to-text)

technology is limited by the change in the technology from discrete speech recognition (e.g., *VoiceType*) to continuous speech recognition (e.g., *Dragon Dictate*) that occurred in 1999. There were an equal number of studies published before and after the technological change; however, not all of the subsequent studies investigated the newer technology (Peterson-Karlan, 2011). Continuous speech recognition continues to evolve and develop technologically with many of the issues of training time and recognition accuracy having been addressed (by developer report) with little if any new empirical studies of its use by students with learning and academic disabilities to support compositional writing. Word prediction shows a similar trend having a peak in 1996-2000 (five studies) and a subsequent decline. As addressed below, all of these declines in well-designed empirical research have an impact upon our ability to formulate conclusions about technology as an evidence-based practice.

Technologies that Support Compositional Writing Across the Critical Writing Processes

Despite the limitations of the overall scope and currency of the evidence base, it is still useful to examine the frequency and characteristics of the research base for the various tools that are available to support each of the four compositional writing processes. In addition, it is also useful to identify what we know and what we do not know based on existing evidence, despite the limited scope. This section will address the overall characteristics and general findings from the research; detailed analyses are available elsewhere (Peterson-Karlan, 2011).

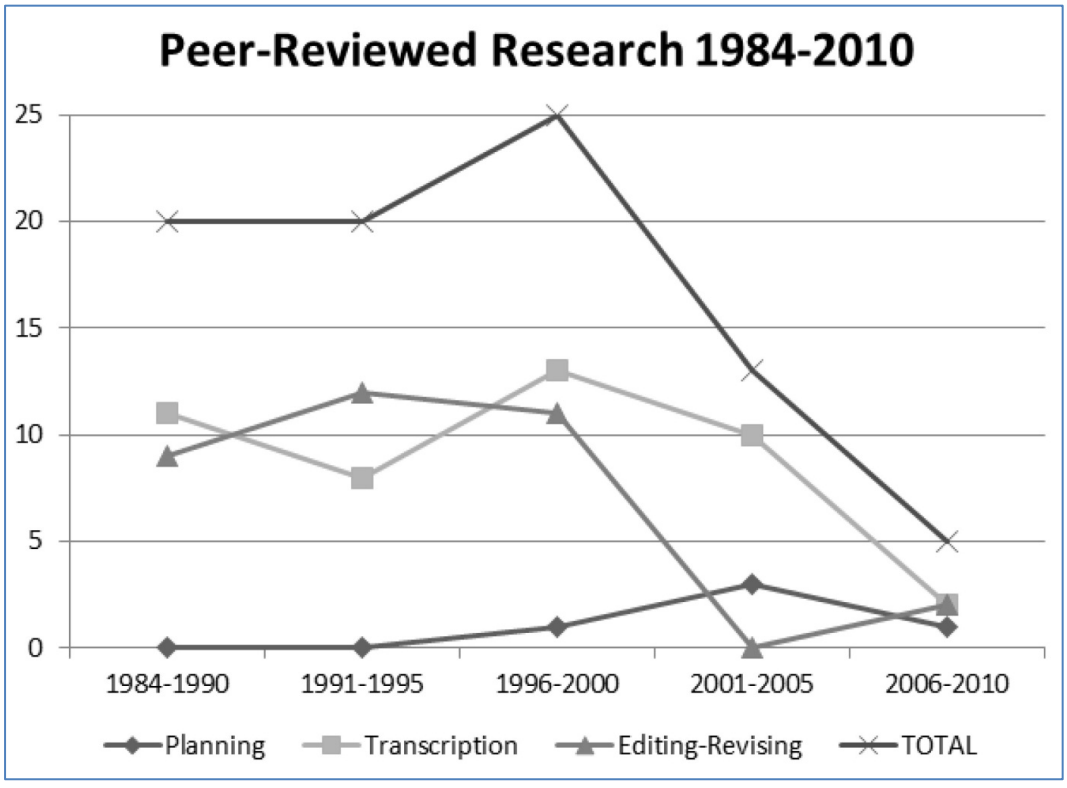

Figure 5. Frequency of applied research with students with learning and academic disabilities.

Technology to Support Planning

There are only five studies in the research base that have examined the effect of using digital planning and organization tools on the compositional writing of students with learning and academic disabilities (see Table 1) [See also Appendix A]. Among these five studies are one that examined the use of a prompted outline tool, and four that examined the use of prompted graphic organizers. In all four studies, these tools were combined with use of a word processor to produce the written composition. 'Prompt' is used here to refer to on-screen text that provides specific content or procedural prompts; if text-to-speech were available, auditory presentation of the prompt was also possible. Unfortunately, three of the studies used technology that is not commercially available; the technology was custom developed for the series of research studies in order to provide 'proof of concept.'

What we do know is based both on direct evidence (i.e., direct investigation of the effectiveness of the digital tool), and indirect evidence (i.e., direct evidence of an effective strategy that is applied to a tool that uses the strategy). A large base of indirect evidence (Englert, Manalo, & Zhao, 2004; Englert, Wu, & Zhao, 2005; Englert, Zhao, Dunsmore, Collings, & Wolbers, 2007; Graham, MacArthur, & Fitzgerald, 2007) suggests that the planning and organization skills of students with learning and academic disabilities can be improved and that tools must provide both procedural facilitation and text structure supports. Market survey indicates that such tools exist (e.g., *Draft:Builder*®; *Kurzweil 3000*; *Read & Write Gold*). However, there is a great need for additional research that directly examines the effectiveness of these tools on the compositional writing of students with learning and academic disabilities.

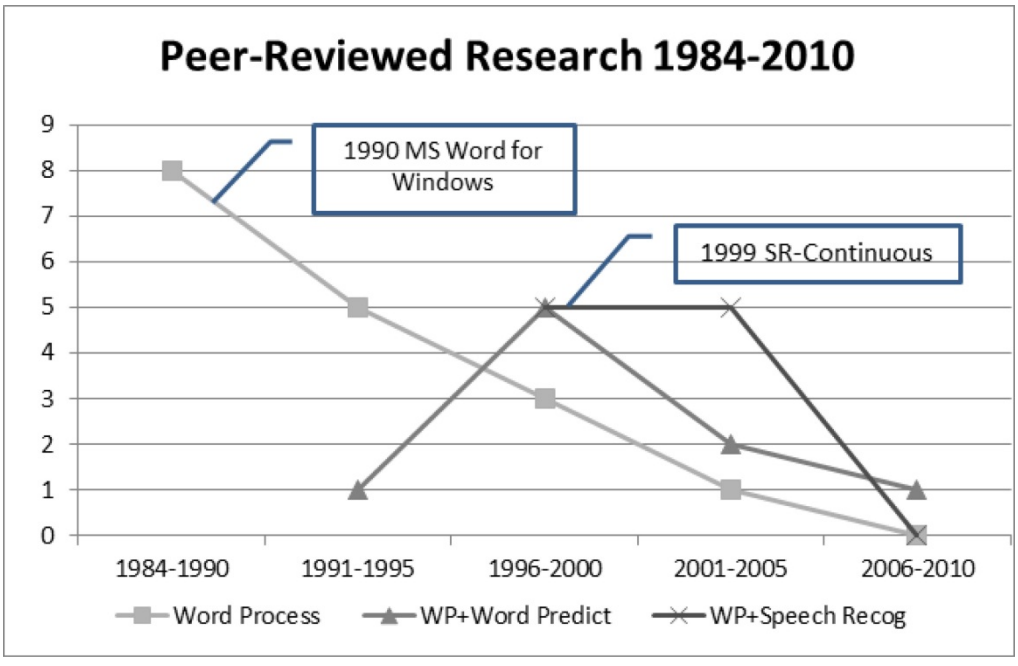

Figure 6. Frequency of applied transcription research studies with students with learning and academic disabilities.

Table 1
Applied Research Studies with Students with Learning and Academic Disabilities by Writing Process and Digital Tool 1984-2010

Writing Process	Digital Tool	*N* of Studies	% of Studies
Plan-Organize	Word Processor (WP) + Prompted Outline	1	20.0%
	WP + Prompted Graphic Organizer	1	20.0%
	WP + Graphic Organizer + Prompts	3	60.0%
Transcribe	Keyboarding	9	20.0%
	Word Processor (WP)	17	37.8%
	WP + Word Prediction	9	20.0%
	WP + Speech Recognition	10	22.2%
Edit	Spellchecker	9	90.0%
	Grammar checker	1	10.0%
Revise	Word Processor (WP)	8	32.0%
	WP + Peer Strategies	10	40.0%
	WP + Procedural Facilitation	2	8.0%
	WP + Digital Prompting	1	4.0%
	WP + Text-to-Speech	4	16.0%

Technology to Support Transcription

There are a total of 45 applied studies in the research base that have examined the effect of transcription tools on compositional writing by students with learning and academic disabilities; this includes (see Table 1) studies of keyboard training or use (*N*=9), word processors use (*N*=17), use of word processors with word prediction (*N*=9), and use of speech recognition word processors (*N*=10). Given the problems associated with technological development discussed above, a number of tentative findings can be drawn from this research. First, word processors used alone increase the legibility of the written composition and increase transcription speed; however, only to the extent that students have obtained 'competent' levels of keyboarding speed. Word prediction, when used with word processors, increases transcription accuracy, may increase word fluency (which was often not measured), and may increase compositional quality (although not directly). Writing quality is a multi-dimensional outcome construct (Graham & Perin, 2007) of which word fluency is only one aspect. Increases in word fluency when using word prediction contribute, in part, to compositional quality but not to the effect that organization or use of detail does, for example. The research with students with learning and academic disabilities using current, continuous speech recognition systems is too limited, and the variables involving both the technology (e.g., recognition accuracy) and the user (e.g., severity of spelling errors, operational competence in transcription and transcription error correction) are too complex to yield any useful tentative conclusions beyond the fact the students can learn to use them to produce written compositions.

Technology to Support Editing and Revising

As used here, editing is the process of 'proofreading' the written composition, either after or during transcription for accuracy of spelling, punctuation and grammar The

Table 2
Criteria for an 'Evidence-Based Practice'

Quasi-Experimental & Experimental Design Studies	Single-Subject Design Studies
There are at least *four acceptable quality studies*, or *two high quality studies* that support the practice; and The *weighted effect size* is significantly greater than zero.	The experimental effects of *minimally acceptable studies* must be replicated across • A minimum of *five acceptable* single-subject studies • Conducted by *at least three different researchers* across *at least three different geographical locations* • And include a total of *at least 20 participants*

primary editing tool that has been investigated is the word processor spellchecker (*N*=9 studies) with only one study found investigating use of a grammar checker by students with learning and academic disabilities (see Table 1). This research yields one preliminary finding: that teaching students with learning and academic disabilities to use spellchecking strategies combined with text-to-speech output spellcheckers increases compositional accuracy. These findings are further limited to the more recent word processors that use new algorithms for identifying errors and suggesting alternative words.

As used here, revising is the process of making improvements to the structure of the composition including organization, coherence, use of detail, etc. There are 25 applied studies of revising written compositions by students with learning and academic disabilities in the research evidence base. The majority these being either investigation of the use of the word processor alone (*N*=8) or in combination with either procedural facilitation (strategy use; *N*=2) or peer review strategies (*N*=10). There are a very small number of studies investigating the use of a digital prompting tool (*N*=1) and use of text-to-speech aided screen review of the written composition (*N*=4). The major limitation to identifying any overall findings is the number of studies; there are only five studies, of all 25, that employed non-case study designs, including only two each for the effect of word processor use and word processor with procedural facilitation, and one study of the use of a digital prompting tool. This is too small a sample to draw any reliable or valid conclusions regarding the effect of technology on revising written compositions by students with learning and academic disabilities.

Conclusions and Implications

The purpose of this literature research was to determine what is known from empirical research on technologies to support writing and whether technology to support writing is an evidence-based practice. Based standards recently proposed for determining whether a practice is evidence-based, Table 2 provides the criteria for 'acceptable' and 'high quality' experimental and quasi-experimental (Gersten et al., 2005) and single-subject designs (Horner et al., 2005).

The terms *acceptable* and *high quality* refer to characteristics of the procedures and methodology of the studies; details of these internal characteristics can be found within the references cited. For this review, it is assumed that the internal characteristics have been addressed through the peer review process, although this will need to be confirmed in follow-up investigations of the

Table 3
Analysis of Technologies to Support Writing as Evidence-Based Practice

	Case Studies	Single Subject	Quasi-Experiment	Experimental	TOTAL
Planning & Organization					
	N Studies				
All Tools	0	0	4	1	**5**
	N Students				
All Tools	--	--	64	35	**99**
Transcription					
	N Studies[a]				
Word Processor (WP)	2	4	3	8	**17**
WP+Word Prediction	2	5	0	2	**9**
WP+Speech Recognition[b]	8	1	1	2	**12**
	N Students				
Word Processor (WP)	12	19	106	794	**931**
WP+Word Prediction	6	21	0	297	**324**
WP+Speech Recognition	45	3	23	72	**143**
Editing					
	N Studies				
Spellchecker	3	1	3	2	**9**
Grammar Checker	0	0	0	1	**1**
	N Students				
Spellchecker	66	3	72	296	**437**
Grammar Checker	0	0	0	203	**203**
Revising					
	N Studies				
Word Processor (WP)	2	1	1	0	**4**
WP+Procedural Facilitation[c]	0	1	0	1	**2**
WP+Digital Prompting[d]	0	0	0	1	**1**
	N Students				
Word Processor (WP)	12	4	11	0	**27**
WP+Procedural Facilitation	0	3	0	28	**31**
WP+Digital Prompting	0	0	0	57	**57**

Notes:
[a] Omitted Keyboarding Studies (*N*=9), [b] Two articles reported 2 studies, [c] Omitted WP+Text-to-Speech (*N*=4), [d] Omitted WP+Peer Strategies (*N*=10)

studies in this evidence base. The focus here is on two necessary conditions: (a) Are there enough studies to establish an evidence-based practice? (assuming that the studies are either acceptable or of high quality); and (b) Are there enough participants in the studies to establish an evidence-based practice? Table 3 presents the results of this analysis using the

evidence base identified for technology to support writing by students with learning and academic disabilities.

Planning and Organization Tools

There is not a sufficient number of experimental or quasi-experimental (N=5) nor are there any single subject design studies to support the use of digital planning and organizing tools as an evidence-based practice (See Table 3).

Transcription Tools

There are a sufficient number of experimental or quasi-experimental design studies (*N*=11) of the effects of word processing on the compositional writing of students with learning and academic disabilities to warrant further analysis and meta-analysis of the necessary effect sizes (see Table 3). There needs to be two additional single-subject design studies before determining whether these studies collectively support the use of the word processor as an evidence-based practice. There is not a sufficient number of experimental or quasi-experimental (*N*=2) design studies regarding the use of word processors with word prediction. One more single subject design study (*N*=5) of word predication used with a word processor is needed; however, there are a sufficient number of participants (*N*=21) to perhaps warrant further meta-analysis of the results of the use of these tools on the compositional writing of students with learning and academic disabilities. There are an insufficient number of either experimental or quasi-experimental (*N*=3) and single subject (*N*=1) design studies to determine whether the use of speech recognition (speech-to-text) combined with word processors is an evidence-based practice. If at least two of the experimental or quasi-experimental were found to be 'high quality' then a conclusion might be possible regarding the use of word prediction and speech recognition combined with word processing as evidence-based practices.

Editing & Revising Tools

The use of spellcheckers as an evidence-based practice to support compositional writing of students with learning and academic disabilities is supported by five experimental or quasi-experimental design studies, but only one single subject design study (see Table 2). If the experimental or quasi-experimental design studies meet the criteria for either acceptable or high quality studies, further analysis or meta-analysis are warranted to determine the necessary effect sizes. Grammar checkers have received little attention in the research on compositional writing by students with learning and academic disabilities; in fact, only one experimental design study could be located. Digital tools to support revising of written compositions by students with learning and academic disabilities has also received little attention, with a total of only seven studies across all three types of tools (see Table 3). There were not even two experimental or quasi-experimental design studies found for any one of the three types of tools (word processor, WP with procedural facilitation, or WP with digital prompting).

Summary

The extent and quality of the digital technology applied research evidence base reviewed here is alarming considering the: (a) importance of compositional writing in post-secondary education and in the workplace; (b) performance of struggling writers, including those with learning and academic disabilities on assessments such as the NAEP; (c) significant trends in writing technology development over the past 25 years; and (d) trends in availability and use of computers and digital technologies by all school-aged children, including those who struggle to

write. While there may be just enough applied research to establish 'promising' technology practices and, in a few cases, perhaps even 'evidence-based practices,' there are major gaps at all levels of the writing process in the applied research base. Of perhaps greatest concern is the fact that the trends in amount or research published in peer-reviewed journals (a necessary criterion for determining an evidence-based practice) is decreasing as digital tools (e.g., netbooks and tablet computers) are increasingly present in school settings.

Given the insufficient size and the extent of outdated technology in the research base, we should be very wary of published work that recommends the use of technology to support compositional writing by these students as though it were an evidence-based practice. Similarly, published conclusions regarding the ineffectiveness of digital writing support technologies are also to be greeted with skepticism. There is one overriding conclusion that presents itself without even the support of meta-analytic analysis of the existing research base: We need *more and better research* on current technologies that support compositional writing by students with learning and academic disabilities and we need it now! The questions to be answered are not new. Is it effective in improving the quality of compositions? While this is the ultimate outcome of students with learning and academic disabilities using technology to write, in the larger scope of a research program, another question is equally, if not more, relevant: How does technology support compositional writing? To address this question, it will be necessary to measure more than compositional quality using, for example, 6-trait rubrics. A range of variables has been identified through systematic synthesis of the existing research that impact the overall quality of compositions produced by students with learning and academic disabilities (Peterson-Karlan, 2011; Peterson-Karlan & Parette, 2007). These variables include, among others, operational competence in using technology, organization and completeness of the content structure of the various compositional writing tasks (e.g., narrative, compare-and-contrast expository, persuasive argument, etc); transcription speed; conventional accuracy (spelling, punctuation, grammar); and word fluency and use of supporting detail. In the systematic program of research that is needed, current and emerging technologies will be integrated with those writing interventions that have been demonstrated to be effective (e.g., Graham, MacArthur, & Fitzgerald, 2007; Graham & Perin, 2007). Such research will systematically expand our knowledge and establish effective technology-supported instructional practices for students with learning and academic disabilities who struggle to write in a digital age.

References

ACT. (2005). *Crisis at the core: Preparing all students for college and work*. Retrieved from http://www.act.org/path/policy/alert/crisis.html

Cochran-Smith, M. (1991). Word processing and writing in elementary classrooms: A critical review of the literature. *Review of Educational Research, 61*(1), 107-155.

Forgrave, K. E. (2002). Assistive technology: empowering students with learning disabilities. *Clearing House, 75*, 122-126.

Gersten, R., Fuchs, L. S., Compton, D., Coyne, M., Greenwood, C. R., & Innocenti, M. S. (2005). Quality indicators for group experimental and quasi-experimental research in special education. *Exceptional Children, 71*(2), 149-164.

Goldberg, A., Russell, M., & Cook, A. (2003). The effect of computers on student writing: A meta-analysis of studies from 1992-2002. *Journal of Technology, Learning, and Assessment, 2*(1), 3-51.

Graham, S., MacArthur, C. A., & Fitzgerald, J.

(2007). *Best practices in writing instruction*. New York: Guilford.

Graham, S., & Perin, D. (2007). A meta-analysis of writing instruction for adolescent students. *Journal of Educational Psychology, 99*, 445-476.

Graham, S., & Perin, D. (2007). *Writing next: Effective strategies to improve writing of adolescents in middle and high schools*. Retrieved from http://www.all4ed.org/publications/WritingNext/index.html

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S. L., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children, 71*, 165-169.

Hunt-Berg, M., & Rankin, J. L. (1994). Ponder the possibilities: Computer-supported writing for struggling writers. *Learning Disabilities Research and Practice, 9,* 169-178.

MacArthur, C. A. (2000). New tools for writing: Assistive technology for students with writing difficulties. *Topics in Language Disorders, 20*(4), 85-100.

MacArthur, C. A. (2009a). Reflections on research on writing and technology for struggling writers. *Learning Disabilities Research and Practice, 24*, 93-103.

MacArthur, C. A. (2009b). Using technology to teach composing to struggling writers. In G. A. Troia (Ed.), *Instruction and assessment for struggling writers* (pp. 243-265). New York: Guilford.

Montgomery, D. J., & Marks, L. J. (2006). Using technology to build independence in writing for students with disabilities. *Preventing School Failure, 50*(3), 33-38.

National Commission on Writing. (2003). *The Neglected R: The need for a writing revolution*. Retrieved from http://www.writingcommission.org/

National Commission on Writing. (2004). *Writing: A ticket to work...Or a ticket out. Retrieved* from http://www.writingcommission.org/

National Commission on Writing. (2006). *Writing and school reform*. Retrieved from http://www.writingcommission.org/

National Council of Teachers of English. (2004). *NCTE beliefs about the teaching of writing*. Retrieved from http://www.ncte.org/prog/writing/research/118876htm

National Writing Project, & Nagin, C. (2006). *Because writing matters: Improving student writing in our schools*. San Francisco: Jossey-Bass.

National Writing Project & DeVoss, D. N., Eidman-Aadahl, E. & Hicks, T. (2010). *Because digital writing matters: Improving students writing online and in multimedia environments*. San Francisco: Jossey-Bass.

Newcomer, P. L., & Barenbaum, E. M. (1991). The written composing ability of children with learning disabilities: A review of the literature from 1980 to 1990. *Journal of learning Disabilities, 24*, 578-593.

Odom, S. L., Brantlinger, E., Gersten, R., Horner, R. H., Thompson, B., & Harris, K. R. (2005). Research in special education: Scientific methods and evidence-based practices. *Exceptional Children, 71*, 137-148.

Okolo, C. M., & Bouck, E. C. (2007). Research about assistive technology: What have we learned? *Journal of Special Education Technology, 22*(3), 19-33.

Parette, H. P., Peterson-Karlan, G. R., & Wojcik, B. W. (2005). The state of assistive technology services nationally and implications for future development. *Assistive Technology Outcomes and Benefits, 2*(1), 13-24.

Persky, H. R., Daane, M. C., & Ying, J. (2002). *The Nation's report card: Writing 2002*. Retrieved from http://nces.ed.gov/nationsreportcard/writing/results2002/

Peterson-Karlan, G. R. (2011). *Technology to support writing by learners with academic & learning disabilities: What we know and what we need to know–1978-2010*. Normal, IL: Illinois State University.

Peterson-Karlan, G. R., & Parette, H. P. (2007a). Evidence-based practice and the consideration of assistive technology.

Assistive Technology Outcomes and Benefits, 4(1), 130-139.

Peterson-Karlan, G. R., & Parette, H. P. (2007b). *Supporting struggling writers using technology: Evidence-based instruction and decision-making.* Retrieved from http://www.cited.org/library/resourcedocs/TechnologyToSupportWritingSummary.pdf

Peterson-Karlan, G. R., & Parette, H. P. (2008). Integrating assistive technology into the curriculum. In H. P. Parette & G. R. Peterson-Karlan (Eds.), *Research-based and emerging best practices in developmental disabilities* (pp. 183-214). Austin: TX: Pro-Ed.

Rogers, L. A., & Graham, S. (2008). A meta-analysis of single subject design writing intervention research. *Journal of Educational Psychology, 100*, 879-906.

Russell, M. (1999). Testing on computers: A follow-up study comparing performance on computer and on paper. *Education Policy Analysis Archives, 7*(20), 1-50. Retrieved from http://epaa.asu.edu/ojs/article/viewFile/555/678

Russell, M., & Abrams, L. (2004). Instructional uses of computers for writing: The effect of state testing programs. *Teachers College Record, 106*, 1332-1357.

Russell, M., Goldberg, A., & O'Connor, K. (2003). Computer-based testing and validity: A look back into the future. Assessment in Education: Principles, *Policy & Practice, 10*, 279-293.

Russell, M., & Haney, W. (1997). Testing writing on computers: An experiment comparing student performance on text conducted via computer and via paper-and-pencil. *Education Policy Analysis Archives, 5*(3), 1-15. Retrieved from http://epaa.asu.edu/ojs/article/viewFile/604/726

Russell, M., & Plati, T. (2001). Effects of computer versus paper administration of a state-mandated writing assessment. *Teachers College Record* [Online]. Retrieved from http://www.tcrecord.org.proxy.lib.ilstu.edu/library/PrintContent.asp?ContentID=10709

Russell, M., & Plati, T. (2002). Does it matter with what I write? Comparing performance on paper, computer and portable writing devices [Electronic version]. *Current Issues in Education 5*(4). Retrieved from http://cie.ed.asu.edu/volume5/number4/

Sitko, M. C., Laine, C. J., & Sitko, C. J. (2005). Writing tools: Technology & strategies for struggling writers. In D. L. Edyburn, K. Higgins, & R. Boone (Eds.), *Handbook of special education research and practice* (pp. 571-598). Whitefish Bay, WI: Knowledge by Design.

U. S. Department of Education. (2003). *Identifying and implementing educational practices supported by rigorous evidence: A user friendly guide.* Retrieved from http://www2.ed.gov/rschstat/research/pubs/rigorousevid/rigorousevid.pdf

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1998, 2002 and 2007 Writing Assessment. (n.d). Retrieved from http://nationsreportcard.gov/writing_2007/w0002.asp

Zhao, Y. (2007). Speech technology and its potential for special education. *Journal of Special Education Technology, 22*(3), 35-41.

Appendix A.

Applied Research on Digital Technology to Support Instruction by Students with Learning and Academic Disabilities

Planning and Organization (*N*=5)

Bahr, C. M., Nelson, N. W., & Van Meter, A. (1996). The effects of text-based and graphics-based software tools on planning and organizing of stories. *Journal of Learning Disabilities, 29*, 355-370.

Englert, C. S., Manalo, M., & Zhao, Y. (2004). I can do it better on the computer: The effects of technology-enabled scaffolding on young writers' composition. *Journal of Special Education Technology, 19*(1), 5-21.

Englert, C. S., Wu, X., & Zhao, Y. (2005). Cognitive tools for writing: Scaffolding the performance of students through technology. *Learning Disabilities Research and Practice, 20*, 184-198.

Englert, C. S., Zhao, Y., Dunsmore, K., Collings, N. Y., & Wolbers, K. (2007). Scaffolding the writing of students with disabilities through procedural facilitation: Using an internet-based technology to improve performance. *Learning Disability Quarterly, 30*(1), 9-29.

Sturm, J. M., & Rankin-Erickson, J. L. (2002). Effects of hand-drawn and computer-generated concept mapping on the expository writing of middle school students with learning disabilities. *Learning Disabilities Research and Practice, 17*, 124-139.

Transcription (*N*=44)

Arnold, V., Joyner, R. L., Schmidt, B. J., & White, C. D. (1997). Establishing electronic keyboarding speed and accuracy timed-writing standards for postsecondary students. *Business Education Forum, 51*(3), 33-38.

Christensen, C. A. (2004). Relationship between orthographic-motor integration and computer use for the production of creative and well-structured written text. *British Journal of Educational Psychology, 74*, 551-564.

Coniam, D. (2001). Word-processing "efficiency" — by means of personalized word-frequency lists. *Journal of Technical Writing and Communication, 31*, 175-187.

Connelly, V., Gee, D., & Walsh, E. (2007). A comparison of keyboarded and handwritten compositions and the relationship with transcription speed. *British Journal of Educational Psychology, 77*, 479-492.

Crealock, C., & Sitko, M. (1990). Comparison between computer and handwriting technologies in writing training with learning disabled students. *International Journal of Special Education, 5*, 173-183.

Cullen, J., Richards, S. B., & Frank, C. L. (2008). Using software to enhance the writing skills of students with special needs. *Journal of Special Education Technology, 23*, 33-43.

Dalton, D. W., & Hannafin, M. J. (1987). The effects of word processing on written composition. *Journal of Educational Research, 80*, 338-342.

Faris-Cole, D., & Lewis, R. (2001). Exploring speech recognition technology: Children with learning and emotional/behavioral disorders. *Learning Disabilities: A Multidisciplinary Journal, 11*(1), 3-12.

Handley-More, D., Deitz, J., Billingsley, F. F., & Coggins, T. E. (2003). Facilitating written work using computer word processing and word prediction. *American Journal of Occupational Therapy, 57*, 139-151.

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

Higgins, E. L., & Raskind, M. H. (1995). Compensatory effectiveness of speech recognition on the written composition performance of postsecondary students with learning disabilities. *Learning Disability Quarterly, 18*, 159-174.

Jacobi, C. (1986). Word processing for special needs students: Is there really a gain? *Educational Technology, 26*, 36-39.

Kerchner, L. B., & Kistinger, B. J. (1984). Language processing/word processing: Written expression, computers and learning disabled students. *Learning Disability Quarterly, 7*, 329-335.

Koorland, M. A., Edwards, B. J., & Doak, P. (1996). Evaluating a systematic keyboarding strategy for students with learning disabilities. *Computers in the Schools, 12*(3), 13-20.

Langone, J., Levine, B., Clees, T. J., Malone, M., & Koorland, M. A. (1996). The differential effects of a typing tutor and microcomputer-based word processing on the writing samples of elementary students with behavior disorders. *Journal of Research on Computing in Education, 29*, 141-158.

Langone, J., Willis, C., & Malone, D. M. (1994/1995). Effects of computer-based word processing versus paper/pencil activities on the paragraph construction of elementary students with learning disabilities. *Journal of Research on Computing in Education, 27*, 171-183

Lewis, R. B., Graves, A. W., Ashton, T. M., & Kieley, C. L. (1998). Word processing tools for students with learning disabilities: A comparison of strategies to increase text entry speed. *Learning Disabilities Research and Practice, 13*, 95-108.

Litten, M. (1999). Introducing voice recognition to dyslexic users in a specialist school. *Dyslexia, 5*, 118-122.

MacArthur, C. A. (1998). From illegible to understandable: How word recognition and speech synthesis can help. *Teaching Exceptional Children, 30*(6), 66-71.

MacArthur, C. A. (1998). Word processing with speech synthesis and word prediction: Effects on the dialogue journal writing of students with learning disabilities. *Learning Disability Quarterly, 21*, 151-166.

MacArthur, C. A. (1999). Word prediction for students with severe spelling problems. *Learning Disability Quarterly, 22*, 158-172.

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

MacArthur, C. A., & Graham, S. (1987). Learning disabled students' composing under three methods of text production: Handwriting, word processing, and dictation. *Journal of Special Education, 21*(3), 22-42.

MacArthur, C. A., Graham, S., & Schwartz, S. S. (1993). Integrating strategy instruction and word processing into a process approach to writing instruction. *School Psychology Review, 22*, 671-681.

MacArthur, C. A., Graham, S., Schwartz, S. S., & Schafer, W. (1995). Evaluation of a writing instruction model that integrated a process approach, strategy instruction, and word processing. *Learning Disability Quarterly, 18*, 278-291.

MacArthur, C. A., Schwartz, S. S., & Graham, S. (1991). A model for writing instruction: Integrating word processing and strategy instruction into a process approach to writing. *Learning Disabilities Research and Practice, 6*, 230-236.

MacArthur, C. A., & Shneiderman, B. (1986). Learning disabled students' difficulties in learning to use a word processor: Implications for instruction and software evaluation. *Journal of Learning Disabilities, 19*, 248-253.

Millar, D. C., McNaughton, D. B., & Light, J. C. (2005). A comparison of accuracy and rate of transcription by adults with learning disabilities using a continuous speech recognition system and a traditional computer keyboard. *Journal of Postsecondary Education and Disability, 18*(1), 12-22.

Morocco, C. C., Dalton, B., & Tivnan, T. (1992). The impact of computer-supported writing instruction on fourth-grade students with and without learning disabilities. *Reading and Writing Quarterly, 8*, 87-113.

Neuman, S. B., & Cobb-Morroco, C. (1987/1988). Writing with word processors for remedial students. *The Computing Teacher* (December/January), 45-47, 61.

Neuman, S. B., & Morocco, C. C. (1987). Two hands is hard for me: Keyboarding and learning disabled children. *Educational Technology, 27*, 36-38.

Nichols, L. M. (1995). A comparison of two methods for teaching keyboarding in the elementary school. *Computers in the Schools, 11*(4), 15-25.

O'Hare, E. A., & McTear, M. F. (1999). Speech recognition in the secondary school classroom: An exploratory study. *Computers and Education, 33*(1), 27-45.

Okolo, C., Hinsey, M., & Yousefian, B. (1990). Learning disabled students' acquisition of keyboarding skills and continuing motivation under drill-and-practice and game conditions. *Learning Disabilities Research and Practice, 5*, 100-109.

Outhred, L. (1989). Word processing: Its impact on children's writing. *Journal of Learning Disabilities, 22*, 262-264.

Quinlan, T. (2004). Speech recognition technology and students with writing difficulties: Improving fluency. *Journal of Educational Psychology, 96*, 337-346.

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

Sanderson, A. (1999). Voice recognition software: A panacea for dyslexic learners or a frustrating hindrance. *Dyslexia, 5*, 114-118.

Utay, C., & Utay, J. (1997). Peer-assisted learning: The effects of cooperative learning and cross-age peer tutoring with word processing on writing skills of students with learning disabilities. *Journal of Computing in Childhood Education, 8*, 165-185.

Vacc, N. N. (1987). Word processor versus handwriting: A comparative study of writing samples produced by mildly mentally handicapped students. *Exceptional Children, 54*, 156-165.

Wetzel, K. (1996). Speech-recognizing computers: A written-communication tool for students with learning disabilities? *Journal of Learning Disabilities, 29*, 371-380.

Williams, S. C. (2002). How speech-feedback and word-prediction software can help students write. *Teaching Exceptional Children, 34*(3), 72-78.

Zhang, Y. (2000). Technology and the writing skills of students with learning disabilities. *Journal of Research on Computing in Education, 32*, 467-478.

Zhang, Y., Brooks, D. W., Fields, T., & Redelfs, M. (1995). Quality of writing by elementary students with learning disabilities. *Journal of Research on Computing in Education, 27*, 483-499.

Editing & Revising (*N*=34)

Borgh, K., & Dickson, W. P. (1992). The effects on children's writing of adding speech synthesis to a word processor. *Journal of Research on Computing in Education, 24*, 533-544.

Cullen, J., Richards, S. B., & Frank, C. L. (2008). Using software to enhance the writing skills of students with special needs. *Journal of Special Education Technology, 23,* 33-43.

Daiute, C. (1986). Physical and cognitive factors in revising: Insights from studies with computers. *Research in the Teaching of English, 20*, 141-158.

Daiute, C., & Kruidenier, J. (1985). A self-questioning strategy to increase young writers' revising processes. *Applied Psycholinguistics, 6*, 307-318.

Dalton, B., Winbury, N. E., & Cobb-Morroco, C. (1990). "If you could just push a button": Two fourth grade boys with learning disabilities learn to use a computer spelling checker. *Journal of Special Education Technology, 10*, 177-191.

Gerlach, G. J., Johnson, J. R., & Ouyang, R. (1991). Using an electronic spell checker to correct misspelled words and verify correctly spelled words. *Reading Improvement, 28*, 188-194.

Graham, S., & MacArthur, C. A. (1988). Improving learning disabled students' skills at revising essays produced on a word processor: Self-instructional strategy training. *Journal of Special Education, 22*, 133-152.

Gupta, R. (1998). Can spelling checkers help the novice writer? *British Journal of Educational Technology, 29*, 255-266.

Jacobi, C. (1986). Word processing for special needs students: Is there really a gain? *Educational Technology, 26*, 36-39.

Jinkerson, L., & Baggett, P. (1993). Spell checkers: Aids in identifying and correcting spelling errors. *Journal of Computing in Childhood Education, 4*, 291-306.

Jones, I. (1994). The effect of a word processor on the written composition of second-grade pupils. *Computers in the Schools, 11*(2), 43-54.

Kurth, R., J. (1987). Using word processing to enhance revision strategies during student writing activities. *Educational Technology, 27*, 13-19.

Lange, A. A., McPhillips, M., Mulhern, J., & Wylie, J. (2006). Assistive software tools for secondary-level students with literacy difficulties. *Journal of Special Education Technology, 21*(3), 13-22.

Lewis, R. B., Ashton, T. M., Haapa, B., Kieley, C. L., & Fielden, C. (1999). Improving the writing skills of students with learning disabilities: Are word processors with spelling and grammar checkers useful? *Learning Disabilities: A Multidisciplinary Journal, 9*(3), 87-98.

Lewis, R. B., Graves, A. W., Ashton, T. M., & Kieley, C. L. (1998). Word processing tools for students with learning disabilities: A comparison of strategies to increase text entry speed. *Learning Disabilities Research and Practice, 13*, 95-108.

MacArthur, C. A. (1994). Peers + word processing + strategies = A powerful combination for revising student writing. *Teaching Exceptional Children, 27*(1), 24-29.

MacArthur, C. A. (1996). Using technology to enhance the writing processes of students with learning disabilities. *Journal of Learning Disabilities, 29*, 344-354.

MacArthur, C. A., & Graham, S. (1987). Learning disabled students' composing under three methods of text production: Handwriting, word processing, and dictation. *Journal of Special Education, 21*(3), 22-42.

MacArthur, C. A., Graham, S., Haynes, J. B., & DeLaPaz, S. (1996). Spelling checkers and students with learning disabilities: Performance comparisons and impact on spelling. *Journal of Special Education, 30*(1), 35-57.

MacArthur, C. A., Graham, S., & Schwartz, S. S. (1993). Integrating strategy instruction and word processing into a process approach to writing instruction. *School Psychology Review, 22*, 671-681.

MacArthur, C. A., Graham, S., Schwartz, S. S., & Schafer, W. (1995). Evaluation of a writing instruction model that integrated a process approach, strategy instruction, and word processing. *Learning Disability Quarterly, 18*, 278-291.

MacArthur, C. A., Schwartz, S. S., & Graham, S. (1991). Effects of a reciprocal peer revision strategy in special education classrooms. *Learning Disabilities Research and Practice, 6*, 201-210.

MacArthur, C. A., Schwartz, S. S., & Graham, S. (1991). A model for writing instruction: Integrating word processing and strategy instruction into a process approach to writing. *Learning Disabilities Research and Practice, 6*, 230-236.

MacArthur, C. A., & Shneiderman, B. (1986). Learning disabled students' difficulties in learning to use a word processor: Implications for instruction and software evaluation. *Journal of Learning Disabilities, 19*, 248-253.

McNaughton, D., Hughes, C., & Clark, K. (1997). The effect of five proofreading conditions on the spelling performance of college students with learning disabilities. *Journal of Learning Disabilities, 30*, 643-651.

McNaughton, D., Hughes, C., & Ofiesh, N. (1997). Proofreading for students with learning disabilities: Integrating computer and strategy use. *Learning Disabilities Research and Practice, 12*, 16-28.

Owston, R. D., & Wideman, H. H. (1997). Word processors and children's writing in a high-computer access setting. *Journal of Research on Computing in Education, 30*, 202-219.

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

Stoddard, B., & MacArthur, C. A. (1993). A peer editor strategy: Guiding learning-disabled students in response and revision. *Research in the Teaching of English, 27*(1), 76-103.

Vacc, N. N. (1987). Word processor versus handwriting: A comparative study of writing samples produced by mildly mentally handicapped students. *Exceptional Children, 54*, 156-165.

Wong, B. Y. L. (1994). Teaching problem learners revision skills and sensitivity to audience through two instructional modes: Student-teacher versus student-student interactive dialogues. *Learning Disabilities Research and Practice, 9*, 78-90.

Wong, B. Y. L. (2000). Writing strategies instruction for expository essays for adolescents with and without learning disabilities. *Topics in Language Disorders, 20*(4), 29-44.

Wong, B. Y. L., Butler, D. L., Ficzere, S. A., & Kuperis, S. (1997). Teaching adolescents with learning disabilities and low achievers to plan, write, and revise compare-and-contrast essays. *Learning Disabilities Research and Practice, 12*, 2-15.

Wong, B. Y. L., L, B. D., Ficzere, S. A., & Kuperis, S. (1996). Teaching low achievers and students with learning disabilities to plan, write, and revise opinion essays. *Journal of Learning Disabilities, 29*, 197-212.