Technology Toolbelt Methodology and Writing Productivity Outcomes In Students with Learning Disabilities

BY

SHERI LENZO
B.S., California State University of Long Beach, 1984

THESIS

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Defense Committee:

Glenn T. Fujiura, Chair and Advisor
Kathy A. Hooyenga
Patricia Politano

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AT	Assistive Technology
CBM	Curriculum-Based Measurement
CCR	College and Career Readiness
IDEA	Individuals with Disabilities Education Act
IEP	Individual Education Plan
LD	Learning Disability
SEAT	Special Education Assistive Technology (Center)
SETT	Student, Environment, Task, Tools
TEST	Task, Environment, Skills, and Tools
TWW	Total Words Written

SUMMARY

This study was designed to evaluate writing productivity outcomes and the technology choices of elementary students with learning disabilities from classroom implementation of a technology 'Toolbelt' framework, which included the following components: (1) A broad range of technologies (including assistive technology) was available and accessible to students within the classroom; (2) Technology was embedded in writing curricula that included instruction in both writing processes and how to use the technology; (3) Technology integrated instruction occurred in whole class lessons that incorporated select empirically based teaching recommendations; and (4) Lessons were planned and taught collaboratively by an assistive technology leader and the classroom teacher. The objective was to combine several factors not previously studied and measured, such as implementing the technology 'Toolbelt' theory with elementary students, integrating AT intervention into curriculum and instruction within a classroom, and supplying teacher training and support concurrent with student instruction.

Pre- and post intervention writing productivity was measured using a paired samples *t*-test to compare the total number of words written by students during a weekly writing activity. Additionally, teachers observed and tallied the types of tools used by students when technology was utilized in the classroom. Students' writing productivity and the type and frequency of technology use, were used to judge the effects of this alternative AT service delivery methodology.

The results indicate that students' wrote significantly more at the end of five weeks than they did in the first week, and that their technology use steadily increased overall. This study found that the technology 'Toolbelt' framework is a promising alternative assistive technology implementation model.

I. CONCEPTUAL FRAMEWORK AND RELATED LITERATURE

A. Background

The impetus for this study began simply with the aim of matching an appropriate assistive technology intervention, for writing, to the needs of students with learning disabilities. In this particular pairing of solution to need, the magnitude and complexity of the variables has proven to be vast. This study of assistive technology in education considers reformation of dated service delivery models, to more effectively fulfill the unmet educational needs of many students with learning disabilities.

Writing remains a daily convention for most people, and a crucial foundational skill for employment; as such, it represents a core outcome of education (Executive Office of the President of the United States, Council of Economic Advisers, 2009; National Commission on Writing, 2003). Yet, learning to write is one of the most complex skills children attain in school, and one many students struggle to acquire (National Commission on Writing, 2003). Unfortunately, writing achievement is below proficiency levels for many students, particularly those identified with a specific learning disability (National Commission on Writing, 2003; Peterson-Karlan & Parette, 2007).

Many educators, special education professionals, and assistive technology specialists agree that technology enhances the performance capabilities of students with learning disabilities (Alper & Raharinirina, 2006; Edyburn, 2005; Wollak & Koppenhaver, 2011). Still, despite federal mandates to consider assistive technology when developing the special education plan of every student, regardless of the type, nature or extent of disability, the educational needs of young writers with learning disabilities, are still largely unmet (Edyburn, 2001b; Edyburn, 2005; Lee & Templeton, 2008).

While the prevalence of technology is generally increasing in schools and classrooms across the U.S., and federal laws have made assistive technology a mandated practice, there appears to remain a number of barriers between students with learning disabilities and

technology they need (Alper & Raharinirina, 2006; Morrison, 2007). In examining this issue, there are a host of interconnected factors that must be understood, including (but not limited to): (1) the complex cognitive, motor, semantic, memory multitask of writing itself; (2) the manifestation of learning disability characteristics when students engage in learning and writing activities; (3) the implementation of federal special education mandates; and (4) the provision of effective empirical interventions. Interventions considered in this study comprise three main categories: evidence-based writing instruction, technologies (general instructional technology and special education assistive technology), and technology integrated instruction (technology and instruction combined). From the preceding list, intervention itself presents another layer, rife with its own set of complications; several factors combine to form obstacles, particularly for technology interventions: (a) few students with learning disabilities are identified for assistive technology (Lee & Templeton, 2008); (b) lengthy consideration processes delay assistive technology implementation for students with disabilities (Edyburn, 2004; Puckett, 2006); (c) sufficient technology resources (computers, devices) are needed for both students and teachers (National Commission on Writing, 2003); (d) student access to available technology is contingent on the knowledge and training of teachers (Alper & Raharinirina, 2006); and (e) guidelines are needed to effectively and consistently integrate assistive technology into the classroom (Edyburn, 2001a, 2004). Lastly, difficulties in providing effective interventions that integrate or rely upon technology are compounded by the operational, and developmental stability of technology itself, and the capacity for the public, and educators, to keep pace; this is somewhat self-perpetuated by the enigmatic nature of technology.

The factors above are daunting enough, and yet there are many other key influences (mandates, initiatives, funding, etc.) in education, which add further complexity as they converge on schools from every level (local, state, national); these influences are acknowledged for their impact on classrooms and their importance in public policy, but will not be components of this study. A brief discussion of the four factors enumerated above will provide a framework for the

purpose of this study, which is to evaluate a method of technology ('Toolbelt') integrated instruction in a classroom of elementary students with learning disabilities, as a potential assistive technology implementation model.

B. **Why Writing**

The importance of writing, as a skill, is underscored by the variety of purposes for which writing is vital, including communication, information gathering, learning, influencing social change, and even reading (National Commission on Writing, 2003). As a powerful lifelong multi-tool, writing is used to communicate & express ideas, information, and art; as a learning tool, creating text enhances students' reading ability, and writing is used to assemble key ideas from text, to review and examine, to personalize and to make connections (Graham, MacArthur, & Fitzgerald, 2013). But the cognitive load and processing requirements of writing are significant. Writing demands the simultaneous cognitive management of memory (spelling, text structures, information, organization and sequencing), output (transcription), and generative thinking, all of which places a sizable demand on the working memory of any writer (Deane, Odendahl, Quinlan, Fowles, Welsh, & Bivens-Tatum, 2008).

Composing meaningful text from thought is accomplished by mentally translating ideas into language and syntactic text structures, which are formed into words and sequenced in an order that conveys the intended message; it involves simultaneously managing and utilizing multiple pieces of transient information, and is the domain of working memory (Batorowicz, Missiuna, & Pollock, 2012; Graham & Harris, 2013; Hayes, 2006). Working memory is limited in both the amount of material it can hold, and the length of time it is retained (Deane, Odendahl, Quinlan, Fowles, Welsh, & Bivens-Tatum, 2008; Hayes, 2006). Various parts of the writing process draw on, and thus compete for, the same limited working memory resources (Hayes, 2006). Hayes characterizes the limitations this way; "Anyone who has composed a brilliant sentence and then forgotten the end of it before it could be committed to paper has experienced one of the problems that limited memory creates for writers" (Hayes, 2006 , p. 28). The role of

working memory in writing and its impact on the performance of students with learning disabilities is an important underpinning to any intervention plan.

C. **Students with Learning Disabilities**

Students with learning disabilities (LD) represent one of the most challenged groups of writers (Englert, Wu, & Zhao, 2005), many of whom find writing to be a perpetually formidable and inescapable task faced in school every day. These students have plenty of ideas but struggle to transfer them into text that expresses, with words, the depth and complexity of their thoughts. Considering interventions, such as assistive technologies, from the learners' perspective helps to identify effective approaches that support specific needs, and increases our understanding of the issues facing students with learning disabilities (Graham & Harris, 2005; McKnight & Davies, 2013). Studies examining the characteristics of writers with learning disabilities are generally in accord, and report a number of shared qualities (Batorowicz, Missiuna, & Pollock, 2012; Graham & Harris, 2005; MacArthur, Ferretti, Okolo, & Cavalier, 2001; Peterson-Karlan G. R., 2011; Peterson-Karlan & Parette, 2007).

Research in cognitive neuroscience reveals that children with learning disabilities lack effective information processing skills compared to their peers; these children have difficulty recalling and regulating the necessary procedural strategies that are central to good writing (Batorowicz, Missiuna, & Pollock, 2012). Writing composition difficulties in students with learning disabilities have been associated with consistent problems related to three recursive writing processes: 1) pre-writing or planning and organizing, 2) transcription or text production, and 3) editing and revising (Batorowicz, Missiuna, & Pollock, 2012; MacArthur, Ferretti, Okolo, & Cavalier, 2001; National Writing Project, 2006; Peterson-Karlan & Parette, 2007). While good writers develop and apply automated or internalized strategies for composing, students with learning disabilities labor through the task without a plan to guide them (Graham & Harris, 2005; National Writing Project, 2006).

To detect the difficulties confronting students with learning disabilities it's helpful to understand characteristics shared by skilled writers. Good writers apply an intrinsic cycle of dynamic planning, drafting, revision, and editing events, whereas struggling writers have difficulty using and adopting steps, or a writing process (Graham & Harris, 2005). Research has established that struggling writers rarely plan ahead of writing, and continue to plan minimally while they write (Graham & Harris, 2005; MacArthur, Ferretti, Okolo, & Cavalier, 2001). Other writing traits shared, to varying degrees, by students with LD include: composing without strategies or procedures for generating and organizing ideas; generating text in an associative way; making more mechanical errors (grammar and spelling in particular); writing less than peers without disabilities; having trouble identifying errors and only correcting some (mainly mechanical errors); and lacking a plan for reviewing (MacArthur, Ferretti, Okolo, & Cavalier, 2001; Peterson-Karlan & Parette, 2007). The difficulty writing presents for students with learning disabilities is reflected by incessantly poor performance in school each year.

Attitudes and beliefs toward writing develop over the school years through repeated writing experiences; at the beginning of elementary school children "want" to write (Boscolo & Gelati, 2013). When writing doesn't improve, or rise to expectations, students become increasingly discouraged; by middle school, many students with learning disabilities assume common maladaptive characteristics toward writing tasks, examples of which include work avoidance (avoiding, or ignoring writing assignments), fulfilling minimum or sub-minimum work requirements, spending minimal time composing, avoiding words they know but cannot spell, and correcting few, if any, errors (Batorowicz, Missiuna, & Pollock, 2012; Wong, 2001). The resulting compositions tend to be sparse or incomplete papers. For students with learning disabilities, these problems with writing become increasingly noticeable as more composition is expected at progressively higher levels of complexity each school year (Kennedy & Deshler, 2010).

To address the full breadth of learning needs (including writing), educational support for students with disabilities was made a national priority with the passage of the Individuals with Disabilities Education Act (IDEA), and subsequently strengthened with the reauthorization of IDEA in 1997, making assistive technology a mandated consideration in the educational planning of every student with a disability (Edyburn, 2001a; Mittler, 2007).

D. **Special Education and Federal Mandates**

Special education offers a vehicle to educational assistance and support for students with learning disabilities. Students who meet school district criteria as having a 'specific learning disability' qualify for special education services under Part B of the Individuals with Disabilities Education Act (IDEA) (Mittler, 2007). Under IDEA, specific learning disability refers to a disorder in one or more of the processes involved in comprehending or using language, spoken or written, that interferes with the ability to listen, think, speak, read, write, or spell; this includes perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia (U. S. Department of Education, 2004a).

IDEA forms the framework for individualized special education and related services for school-age children with disabilities. An Individual Education Plan (IEP) is developed to stipulate the manner and amount of special education services each student with a disability will receive, and includes associated educational goals for those services (U.S. Department of Education, 2004b). Of the students receiving special education services rendered through an IEP, those with a specific learning disability represent the largest single group of students according to the most recent data from the U.S. Department of Education (Figure 1) (The Technical Assistance and Dissemination Network, 2012); students in this category are typically included in regular (general education) classrooms, and frequently have identified learning needs and IEP goals related to literacy skills (reading and writing).

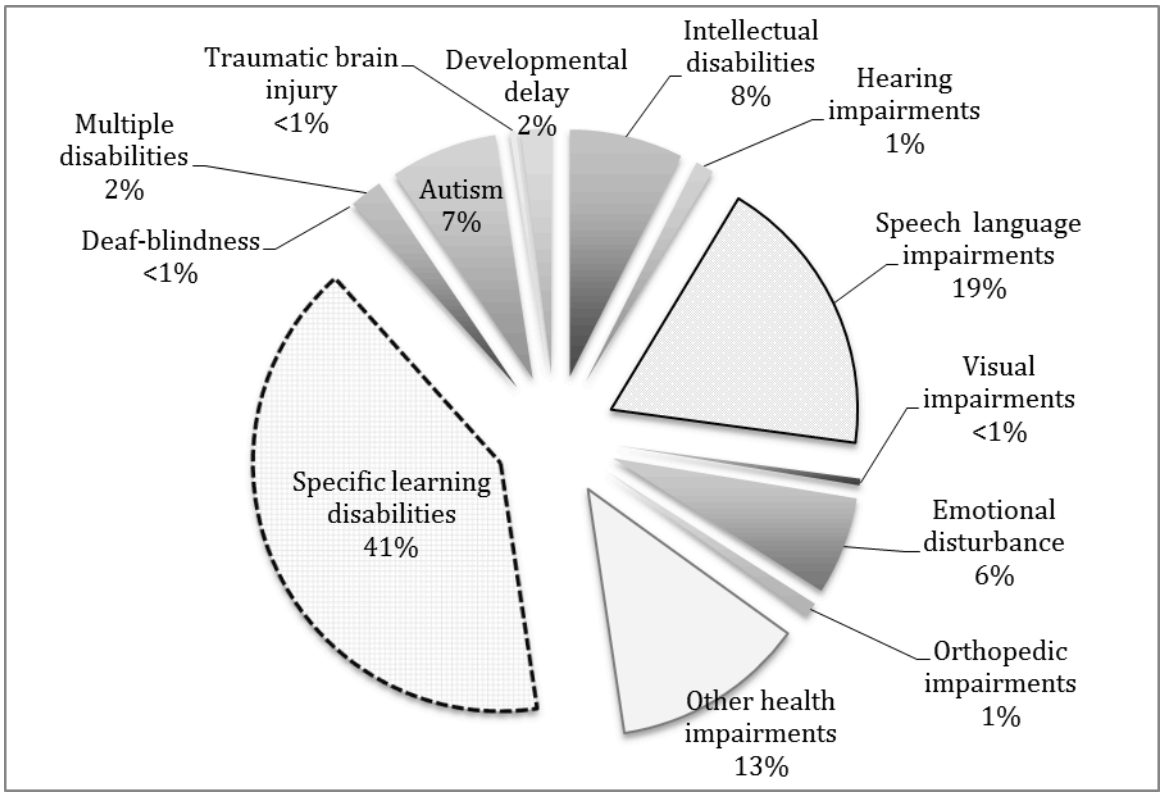

Figure 1. Percentage of all children receiving special education services. U.S. and outlying area 2011 IDEA Data showing the percentage of all children receiving special education services, by category of disability. Specific learning disability represents the highest percentage of students receiving services. (The Technical Assistance and Dissemination Network, 2012).

Assistive Technology (AT) serves as a support or scaffold for students, by offering a range of compensatory tools and accommodations that offset the effects of disability. All students with an IEP, no matter the type or definition of their disability, are assured under the IDEA of ‘consideration of special factors’; among those factors is to, “Consider whether the child needs assistive technology devices and services” (U.S. Department of Education, 2004b). An assistive technology (AT) device or tool includes any item used to increase, maintain, or improve the functional capabilities of a child with a disability (U. S. Department of Education,

2004c), and the application of AT encompasses a wide array of functional and academic tasks. Although writing deficits are routinely reported in the IEP's of students with learning disabilities, assistive technology tools that support writing are seldom recommended or included as a supplemental intervention or accommodation (Edyburn, 2005; Lee & Templeton, 2008). Despite the IDEA's AT provision for all students with an IEP, it seems that assistive technology is unaccountably absent from the education plans of most students with learning disabilities (Edyburn, 2001a).

E. **Writing Interventions**

The literature on writing interventions for students with learning disabilities will be considered in three categories: writing instruction, technology interventions, and technology integrated instruction (technology embedded within instruction). Interventions are discussed in order of technical sophistication, from non-technical (instruction) interventions, to specialized technology for students with learning disabilities (assistive technology).

1. **Writing instruction**

The most fundamental of the recommendations from research on writing instruction simply states students need to spend more time writing; all students should write daily for a variety of different purposes, from notes to narratives, reports, and all genres of composition (Peterson-Karlan & Parette, 2007; National Writing Project, 2006). There is ample research on best practices in writing instruction for students with learning disabilities, much of which supports focused instruction in the particular shared deficit areas of writers with learning disabilities, including teaching the recursive writing processes, strategies and procedural techniques for pre-writing, planning, organizing, and text structure (Englert, Zhao, Dunsmore, Collings, & Wolbers, 2007; Graham & Harris, 2005; Peterson-Karlan & Parette, 2007).

Writing well depends on using strategies that help writers by focusing cognitive and attention resources on a specific group of writing steps (Deane, Odendahl, Quinlan, Fowles, Welsh, & Bivens-Tatum, 2008). Gersten and Baker highlighted three essential components of

effective writing interventions: (1) explicitly teach the recursive writing processes: plan, generate sentences, revise; (2) provide students with a framework, prompt, or planning guide (similar to a sample or model); and (3) teach students revising skills through interactive dialogues with teachers and peers (Gersten & Baker, 2001). Similarly, Blackhurst described the '*technology of teaching*' as instructional approaches that are systematically designed and applied in precise ways, based on tasks students must learn, carefully sequenced in small units of instruction, with high levels of student involvement, generous reinforcement, and close monitoring of student performance (Blackhurst, 2005).

Considering the impact of writing tasks on working memory illustrates some of the benefits of writing strategies to students with LD. Since working memory has limits, applying tools and procedures that offload the cognitive demands can enhance working memory, leaving better capacity for developing ideas (Hayes, 2006). At a basic level the organization of text into specific text structures provides composition models (Deane, et al., 2008). Text structure instruction helps students acquire a better knowledge of how texts are conventionally organized and what patterns are used for various genres, such as factual reports, explanatory text, compare and contrast, persuasion, and narratives (Graham & Harris, 2005; MacArthur, Graham, Haynes, & DeLaPaz, 1996). Writing frameworks can aid memory by supplying simple, mnemonic procedural prompts to guide the writer; Hayes offers the example of the five W's – who, where, when, what, why – as a framework for producing or editing a news story (Hayes, 2006).

A large body of work, including studies sponsored by the U.S. Department of Education, provides considerable evidence for explicit instruction, a well-documented instructional approach (Archer & Hughes, 2011; Hall, 2002; Swanson, Harris, & Graham, 2003). Explicit instruction is characterized as systematic, direct, engaging, and (student) success oriented (Archer & Hughes, 2011). The basic overall structure of an explicit lesson has three parts, which generally transpire swiftly: (1) opening the lesson – state the goal of the lesson, discuss the

relevance of the skills, and review prerequisite skills; (2) the body – skill development; and (3) closing the lesson – review critical content, preview the next skill, and assign independent work (Archer & Hughes, 2011). Instruction of new content occurs in the body of the lesson and includes three processes: (a) modeling (I do it) in which the teacher demonstrates the skill using clear, consistent, and concise language; (b) prompted or guided practice (we do it) using physical, verbal, and visual prompts (steadily faded), and scaffolding (tell, ask, remind students what to do); and finally (c) unprompted practice (you do it), independent application of the skill and opportunity for students to demonstrate understanding (Archer & Hughes, 2011). Explicit instruction embodies other important learning conditions, including: creating a positive learning environment, actively involving students throughout the lesson, allowing sufficient time for academic instruction, monitoring performance and providing feedback (Archer & Hughes, 2011; Hall, 2002).

Another instructional method, the constructivist or student-centered approach, bears mentioning as well since it has gained some interest in the field of education, although supporting evidence is limited. This method of instruction is generally based on exploratory learning through problem solving, trial and error, and an experiential schema that allows students to construct knowledge for themselves, a method seemingly best suited for experienced learners with well-developed background knowledge in the lesson content area (Archer & Hughes, 2011). Using this model, experienced learners draw on their long-term memory (knowledge base and experience) to answer questions and discover solutions with minimal support, reserving adequate short-term memory to process and utilize complex new information. Novice or intermediate learners, by contrast, lack knowledge or experience to draw from; they must manage new information and problem solving within the limited capacity of short-term memory (information stored for 30 seconds or less) (Archer & Hughes, 2011). Manipulating and applying novel information solely with short-term memory is difficult, and may result in cognitive ‘overload’ (Archer & Hughes, 2011). The constructivist principals of

exploration and discovery may have merit, however for students with LD this method should be carefully dispensed, and limited to activities likely to result in success rather than frustration.

In general, struggling writers need, and benefit from instruction in the writing processes: planning, transcription, and editing and revising (Peterson-Karlan & Parette, 2007). However, despite the efforts of teachers to apply a variety of instructional methods and materials, individual instruction, composition models, and motivational inducements, many students with learning disabilities remain unable to perform the task of writing under the conditions expected of all students, without variance of tools or options (Swanson, Harris, & Graham, 2003). Edyburn (2006) adroitly captures the ingrained efforts, and outcome shortfalls of instructional practices, as follows.

> Teachers are extremely comfortable with the options associated with remediation: reteach the information, use alternative instructional strategies, break the tasks down into smaller parts to analyze what the child knows and what components are problematic, reduce the number of items that must be completed, provide additional practice, engage in one-on-one tutoring, etc. However, if instruction and remediation approaches always worked, we would never see secondary students struggling with developmental tasks like decoding, solving basic math facts, and handwriting that interfere with higher level performance. (p. 22)

2. **Technology interventions**

a. **Instructional technology**

Technology in education is an increasingly pervasive element in school districts and classrooms everywhere, and it's purposes, and applications as a learning, teaching, communication, creativity and discovery tool have grown and altered at a staggeringly rapid pace in the past few years. Modern technology has been a presence in education for decades, but in recent years technology advances have surged at unexpected rates, challenging our understanding of its capacity, and the way it's defined in education. For ease of consideration, technology in education will be categorized into two main purposes: general instruction (Instructional Technology) and augmentation or compensation (Assistive

Technology). General technology in education, used to deliver and support student instruction and learning (Instructional Technology), encompasses a wide swath of technologies ranging from programs created for education that remediate or reinforce specific skills, to common commercial products such as remote screen projection and mobile computing, business and office productivity applications, a host of Internet-based tools and services, art, music, design, research, general purpose, entertainment, and social media applications.

Instructional technology has become a prevalent commodity in education, applied universally across all classrooms; it manifests in a number of transitory forms, such as hardware, software, and Internet technologies, varying across regions of the U.S. as much as among neighboring school districts. The evolutionary pace of technology has so accelerated, that any description of 'Instructional technology' is fleeting; nevertheless, in her chapter on "Best Practices Using Technology to Support Writing", Karchmer-Klein's categorization of 'Apps' (educational applications for tablet computers) is helpful and can be suitably applied to sub-categorize instructional technology this way: (a) the first sub-category includes technologies that independently teach or reinforce specific content; and (b) the second includes technologies that are more multi-purpose and embedded within teaching practices (Karchmer-Klein, 2013). In the first category, the purpose of instructional technologies designed to teach or reinforce content is largely to review and practice existing skills, or provide remediation; this technology is designed for students to use independently, focuses on isolated academic skills (Karchmer-Klein, 2013), and will not be included in this study. In contrast, technologies embedded in instruction tend to be comprised of generally conventional, universal, multi-purpose tools and applications, used by students to process (experience, analyze), produce, and apply educational content (Graham & Harris, 2013). Instructional technologies include such basics as word processing, and Internet search engines, routinely implemented throughout general and special education. The primary role of instructional technology in education is neatly characterized by Parette and Peterson-Karlan as aiding three desired learning outcomes of instruction: increased (a) instructional

effectiveness – learning objectives are accomplished more effectively than if technology had not been used; (b) instructional efficiency – learning is accomplished in a shorter amount of time; and (c) instructional appeal – students are more engaged in the learning task than if technology had not been used (Parette & Peterson-Karlan, 2007). Considering the Interminable nature of technology innovation, the possibilities for instructional technology are limitless.

b. **Assistive technology**

Assistive technology is administered through special education, and furnishes a compensatory workaround to augment disability-related barriers interfering with the academic or functional performance of students with disabilities (Parette & Peterson-Karlan, 2007). The general field of Assistive technology is vast, serving all individuals with disabilities through a continuum of supportive technologies, equipment, and resources, spanning a lifetime. For the purposes of this study, assistive technology refers to educational contexts governed by the Assistive Technology Act of 1998, and the Individuals With Disabilities Education Act (reauthorized in 2004). Assistive technology in education assumes a variety of forms and functions, and encompasses technology and non-technology tools, mechanical equipment, aids, specialized instructional materials, services, and strategies that students with disabilities use to (a) assist them in learning, (b) make the environment, including the curriculum, more accessible, and (c) enhance their independence (Blackhurst, 2005).

The difference between instructional technology and assistive technology (AT) is noticeably distinctive for students with low incidence, complex, or compound disabilities. However, the difference among instructional and assistive technologies necessary for students with learning disabilities is far less evident, particularly since commercial technologies have adopted many specialized features once available only as obscure, discrete technologies (Parette & Peterson-Karlan, 2007). Just a decade ago, utilities such as text readers and voice dictation tools, now common in modern technologies (from smart phones to computers), were costly, cumbersome additions to computer systems. The effect of incorporating these and other

specialized tools into conventional technologies disposes general technology toward a universal design that serves a wider range of individuals (Lee & Templeton, 2008). Universally designed products contain attributes that enable use by individuals with disabilities without any additional adaptation, and individuals without disabilities benefit from the same attributes as well (Edyburn, 2010). Now teeming with features universally beneficial to a wider population, mainstream technology contributes some assistive technology functions for students with disabilities. The importance of assistive technology to individuals is the utility it provides to offset effects of disability, the type or source of technology matters little. Blackhurst (2005) puts it into perspective this way:

> While an understanding of the different types of technology is important, our primary concerns should relate to issues such as making decisions about the types of technology that are most appropriate for individual students and ensuring that those technologies are obtained, implemented appropriately, and evaluated to determine their effectiveness. (p. 177)

The field of Assistive Technology in Special Education has amassed a modest body of evidence to support a variety of technology applications targeting specific purposes, and to recommend general technologies for particular disability categories (Alper & Raharinirina, 2006; Batorowicz, Missiuna, & Pollock, 2012; MacArthur, Ferretti, Okolo, & Cavalier, 2001). However, owing to the vast array of disability categories, and the unique, often singular, needs of individuals with disabilities, combined with the lack of standardized measures for assistive technology outcomes, the speed of technology regeneration, and finally the challenges of conducting social research in education settings, the base of assistive technology research that might universally, or explicitly, inform practices, is sparse (Alper & Raharinirina, 2006; Edyburn, 2001a; Okolo & Bouck, 2007).

Studies of assistive technology writing interventions for individuals with learning disabilities have had mixed results, which appear to directly correlate with the presence or absence of instruction integrated with technology interventions (Batorowicz, Missiuna, &

Pollock, 2012; MacArthur, Ferretti, Okolo, & Cavalier, 2001; Wong, 2001). The evidence is slight, yet Batorowicz, Missiuna, & Pollock (2012), found that various assistive technologies for writing (e.g., word prediction, phonetic spell checkers, text-to-speech), generally benefited the academic performance and behavior of students with learning disabilities. Much of the work in AT related to students with learning disabilities and writing has considered word processing tools, spell checking tools, word prediction, concept mapping or planning tools, and variations of combinations of these and other tools.

Much of the research in AT for writing concerns technologies to enhance transcription, such as word-processing (Peterson-Karlan, 2011). Transcription, the conversion of ideas into text, is a relentless hurdle for most students with learning disabilities (Graham & Harris, 2005; MacArthur, Ferretti, Okolo, & Cavalier, 2001). Word processing is a universal transcription tool, and a common recommendation for students with learning disabilities (Connelly, Gee, & Walsh, 2007). However, many studies have reported disadvantages to word processing when keyboarding skills are below proficiency: students compose at a slower rate, make more corrections while writing, derive little benefit to improving the quality of their writing, and in some cases produce poorer results when keyboarding (Connelly, Gee, & Walsh, 2007; Hetzroni & Shrieber, 2004). Similarly, MacArthur et al., (2001) in a review of the research comparing word processing and handwriting in students with learning disabilities, concluded that aside from slower composing rates with word processing (for students lacking typing fluency), there was little difference in the overall quality of writing. When students need to focus on transcription skills (finding/forming letters, spelling), the cognitive demand of writing increases, leaving less available working memory for composition skills, such as organization, genre, and voice (Batorowicz, Missiuna, & Pollock, 2012). Replacing one method with a different text generating method equates to a new task, with unfamiliar processing requirements that take time to learn (Swanson, Harris, & Graham, 2003). All text generating tools and compensatory technologies, including keyboarding, word prediction, and voice-to-text recognition, require user competence

and technological reliability in order to be effective transcription strategies. Any student having to devote attention to processes that should be somewhat habitual is left with less working memory available to develop the content and style of the writing, whether the method is paper and pen, keyboarding, or voice, (Graham, MacArthur, & Fitzgerald, 2013). Methods used to introduce assistive technology to students must consider the above factors in addition to students' performance capabilities with and without technology and the contexts in which AT is needed (Alper & Raharinirina, 2006). The context for AT in education is primarily the classroom, and evidence confirms that combining AT with instruction yields the greatest benefit to students with learning disabilities (Alper & Raharinirina, 2006; Batorowicz, Missiuna, & Pollock, 2012; MacArthur, Ferretti, Okolo, & Cavalier, 2001; Wong, 2001).

3. **Combined interventions: Technology integrated instruction**

Technology integrated instruction represents a hybrid of technology instruction embedded imperceptibly within content instruction. The technology integrated lesson focuses on content area, or academic, development (such as writing), while technology is secondarily employed as a natural tool, demonstrated in a functional and meaningful context. Three studies examined several peer-reviewed articles related to technology writing interventions that involved children with learning disabilities in school; the findings were consistent. MacArthur et al. (2001) reviewed several studies, which primarily considered word processing and transcription tools, concluding that word processing tools alone had limited effect on students' writing, but benefits were enhanced by including instruction in both writing techniques and the operation and capabilities of technology (MacArthur, Ferretti, Okolo, & Cavalier, 2001). Wong's appraisal of this area of research is decisive; students with learning disabilities demonstrate greater improvements in the quality and quantity of their writing when technology (operation) instruction is combined with writing process instruction (Wong, 2001).

The majority of the research studies reviewed by Batorowicz, Missiuna, and Pollock (2012) also examined word processing and transcription tools, and measured the quality and

quantity of students' writing. When technology interventions did not incorporate instruction, the results were inconsistent and contradictory, as in five studies that compared word processing to handwriting: two reported no difference in the quality of writing between the methods; one reported compositions produced with word processing were better organized and had fewer spelling errors, but no difference in length; one reported longer compositions with word processing; and one reported longer essays with handwriting (Batorowicz, Missiuna, & Pollock, 2012). By contrast, all three studies of word processing integrated with instruction reported unvarying positive effects: longer compositions, fewer spelling errors, and improved writing quality (Batorowicz, Missiuna, & Pollock, 2012). Results were similar across the different studies, and the overall conclusion consistent with previous reviews: better student performance when technology was combined with instruction (Batorowicz, Missiuna, & Pollock, 2012).

Technology connects students with learning disabilities to the general curriculum, increasing the probability that all students will participate in and profit from classroom involvement (Puckett, 2006). Assistive technology moderates disability related difficulties that otherwise interfere with learning, consequently enhancing productivity, reducing cognitive or physical effort or time, and ultimately improving the self-sufficiency, accuracy, or quality of students' work (Parette & Peterson-Karlan, 2007). Given mounting evidence for the educational benefits of technology, along with federally mandated consideration of AT for all students with disabilities, the presence and integration of technology in classrooms would seem assured, yet obstacles remain between the potential technology holds for students and the reality of the classroom (Morrison, 2007). Impediments between assistive technology and students with learning disabilities exist at several levels; some include funding for technology, obtaining and deploying enough technology for all students, school district bureaucracy, inter-departmental coordination and communication hurdles, an adequate and reliable infrastructure from which to operate technology, long-term planning for technology recycling and updating, and finally, positioned directly between students and technology in classrooms are teachers untrained and

unprepared to integrate technology with curriculum and instruction. Professional development is imperative in order for teachers to develop the knowledge and skills necessary to integrate technology with instruction (Blackhurst, 2005).

F. **Professional Development**

Professional development for teachers and other related specialists involved with students is as crucial as the interventions themselves. Not only are adequate technology skills, knowledge, and competencies essential (Alper & Raharinirina, 2006), equally important is the capacity to comprehensively teach writing (National Commission on Writing, 2003), and to effectively combine technology and instruction (Wong, 2001).

Technology in classrooms is rendered immaterial when teachers lack the skills to utilize and embed technology into instruction, and lack resources necessary to learn the best methods for teaching and supporting technology (Morrison, 2007). Morrison reviewed factors relative to implementing AT in education and found that scarcity of teacher time, limited training, inadequate technology support, poor leadership, and the lack of a collective vision or foundation for technology use were common problems cited by teachers (2007). Morrison also reported teachers' comfort level with technology was closely related to training issues. In two studies teachers' interest in using technology was affected by their perceptions that additional training would be required or the technology would be appropriate for just a few of their students (Morrison, 2007). Another study, reported by Morrison, found that teachers were less willing to accept the use of classroom technology if they thought it would require them to alter their teaching practices (Morrison, 2007).

A review of the literature reveals classroom obstacles between students and technology use in two areas: (1) lack of teacher professional development and sustained classroom support, and (2) a resistance from some teachers uncomfortable with technology and with the prospect of altering teaching styles to accommodate technology (Morrison, 2007). Professionals' lack of knowledge about technology can be a major obstacle; and adding to the

problem, training programs for special education teachers include few courses or class sessions on assistive technology interventions and issues (Alper & Raharinirina, 2006). Effective technology integration requires strategic design and planning that links curriculum with technology tools, and includes specific instructional objectives (Englert, Zhao, Dunsmore, Collings, & Wolbers, 2007; Graham & MacArthur, 1988; Morrison, 2007). To ensure assistive technology for every student with a learning disability, including access to appropriate equipment and services, it is imperative that teachers and support professionals develop the skills that will permit them to recognize the need, provide assistive technology services, and document assistive technology plans in the IEP (Blackhurst, 2005; Edyburn, 2001b).

G. **Access To Assistive Technology**

1. **Overview**

Although assistive technology is a mandated consideration for all students, few students with learning disabilities are identified for, or have access to, assistive technology, and there is little evidence that school districts have policies or practices designed to consider the needs of these students (Edyburn, 2006). In a 2005 survey of ten U.S. states, the National Assistive Technology Research Institute at the University of Kentucky found that assistive technology is more likely to be used by special education students with low-incidence disabilities (e.g., autism, multiple disabilities), than by students with learning disabilities (Reisberg, 2009); this may be the result of a lingering misconception in education, that AT is only for students with severe disabilities (Lee & Templeton, 2008). The documented effectiveness of AT on learning for students with disabilities and the IDEA promise of AT consideration for all students with an IEP notwithstanding, there continues to be confusion among teachers and special education providers about when technology should be used by students with learning disabilities (Edyburn, 2006). While a student's IEP may target the planning, transcription, and revision process, assistive technology tools supporting these procedures are habitually nonexistent for students

with learning disabilities, even as these technologies have become more generally available in schools.

2. **SETT framework**

Assistive technology consideration in special education, including student evaluation or assessment, is predominantly a purposeful decision-making process conducted collaboratively by a student's entire IEP team (SEAT Center Illinois State University, 2012; Watts, O'Brian, & Wojcik, 2004). There have been a number of consideration models developed to guide this process; one of the most recognized processes for considering and recommending assistive technology in U.S. education is the SETT (Student, Environment, Task, Tools) framework (Edyburn, 2001b; Lee & Templeton, 2008; Watts, O'Brian, & Wojcik, 2004). Introduced in 1994, SETT has historically provided special education teams with a systematic process for considering and documenting AT assessments for individual students. The process follows the SETT acronym, beginning with the Student's skills (identify the student's abilities and limitations), next Environment (the locations and conditions the student needs to be able to perform within), then Task (what the student needs to accomplish), and finally Tools (equipment and strategies that enable the student to perform the task) (Zabala, Bowser, & Korsten, 2004-2005). When first introduced, 20 years ago, the SETT process offered a wholly needed framework that helped guide special education teams and assistive technology providers to consider and support the needs of students with a range of disabilities. During the 1980's and 1990's, assistive technology was an emerging field, with relatively few practitioners, and limited options for professional affiliation or training (Edyburn, 2001a); additionally, technology itself was emerging as a public commodity, with computers just beginning to gain a foothold in schools. Since its inception, the SETT framework has provided a guide for school teams to consider the unique needs of each, individual student, in a definitive 'one student at a time' approach to assistive technology provision. This initial model was suited to an era of emergent technology, but given the current profusion of ever-increasing technologies, from computers to

pocket-sized multipurpose devices, which harbor the very features that nineteen years ago were available exclusively as highly specialized, costly, even ungainly technology to a few fortunate individuals, SETT and similar delivery methods, now have some relative disadvantages.

Traditional AT delivery systems have not changed significantly since they originated; operating primarily as referral-based processes, teachers first identify and refer students for an assistive technology evaluation before a student can receive interventions (Edyburn, 2005). In this, still common, approach to AT in education, the SETT framework is employed in the evaluation (and re-evaluation) process, and yields individual AT recommendations for the student evaluated. AT models like this encompass well-developed, systematic procedures to aid school teams in the documentation and selection of AT for individual students (Watts, O'Brian, & Wojcik, 2004). However, critics of this model have noted the disadvantages of emphasizing procedures associated with selecting AT for individual students, compared to the dearth of guidelines for functional integration of technology, and student performance outcomes (Edyburn, 2005).

The individual student orientation of SETT is now a significant drawback; a ‘one student at a time’ approach to matching students and technology pointedly constricts access to assistive technology for a large number of students. An extensive individual assessment process isn’t necessary for most students with high-incidence learning disabilities; it merely delays access to valuable interventions, and adds to the large underserved population of students who might otherwise be using AT instead of waiting to be identified and evaluated for it (Edyburn, 2001a). As a result it seems school districts, their teachers, and related service specialists are without an effective AT service delivery method that ensures timely access to appropriate devices and services for all students who need assistive technology, as mandated by the IDEA.

Another shortcoming of models like SETT in the twenty-first century is the absence of activities or criteria for student participation in the selection process. Aside from the importance of student engagement in the selection of their own technology, students must also be prepared

to examine, explore, and master new technologies for a lifetime; the development of self-sufficiency in examining and choosing technology is vital to life and employment in the modern age. Student involvement isn't a prevailing factor in typical AT delivery models; there are no delineated student roles in task analysis, decision-making, or self-selection of technology. While students have a minor role in SETT, and similar consideration frameworks, the process is primarily oriented toward adult (parent, teacher, therapist), rather than student (user), decision-making (Watts, O'Brian, & Wojcik, 2004). It has become evident, that this model is not, and can not, fully meet the educational needs of all students with disabilities, and that new alternatives are necessary to effectively deliver assistive technology (Edyburn, 2001a, 2001b, 2004, 2005, 2006; and Puckett, 2006).

3. **Alternative AT delivery systems: 'Toolbelt' and toolkit methods**

The propagation of technology in education has exposed an aging AT delivery system, which is ill-equipped to inform school districts about consideration and implementation practices appropriate for modern classrooms; in particular, effective, yet practical approaches to meeting the AT requirements of every student with a disability. Given this lack of effective service delivery guidelines, it is not surprising that AT, for students with learning disabilities, receives little notice or adherence in most school districts. Edyburn, for more than a decade, has heralded a disparity between the number of students who need and qualify for assistive technology, and the number who actually receive access to it (Edyburn, 2001a). AT guidelines, if insufficient in the past, are inevitably inadequate to meet the needs of students under current and evolving educational circumstances. Modernized service delivery models that address the challenges of providing and supporting effective and timely assistive technology interventions to all students with disabilities are urgently needed (Edyburn, 2006; Puckett, 2006). Regardless of funding availability, the IDEA unequivocally requires the consideration of assistive technology for every student receiving special education (Mittler, 2007; Lee & Templeton, 2008). Thus it is incumbent upon school districts to explore suitable, cost effective alternatives to fulfill this

obligation. Although, meeting educational requirements and achieving the best possible outcomes for students are first priority, effective cost management and the provision of excellent services to all students, are not mutually exclusive aims.

Edyburn has repeatedly argued for the concept of universally equipping classrooms with common technologies that are known to benefit many students, supplanting protracted assistive technology evaluations with readily available technology tools (Edyburn, 2001a, 2001b, 2004, 2005, 2006). Despite the perennial appeal for effective and appropriate AT consideration and intervention policies and practices in education, very few studies have undertaken this issue. However, in recent years two AT intervention models have been gaining traction, the Technology Toolkit model (Puckett, 2006), and TEST (Technology, Environment, Skills, Tools) 'Toolbelt' Theory (Socol, 2005).

The Toolkit model embodies a popular social technology trend in which various digital technologies are grouped into an implicit toolkit, analogous to tangible tools stored in a toolbox. The technology toolkit has existed in special education for several years, often associated with Universal Design for Learning; toolkits represent an assembly of tools, typically comprised of a variety of technology programs and AT items that support a range of purposes (writing, reading, math, organization) (Janowski, 2007; Lee & Templeton, 2008; Puckett, 2006). Technology toolkits are mentioned in the literature as generally useful and beneficial technology delivery methods designed to equip classrooms with assistive and universal technologies as a means of increasing technology access for all teachers and students (Hourcade, Parette Jr., Boeckmann, & Blum, 2010; Lee & Templeton, 2008; Puckett, 2006).

Much of the literature in this area discusses the rationale of the toolkit approach, which is principally to increase students' access to AT, in any classroom, in order to fully participate and profit from their education, and in some studies toolkits are described along with examples of the technologies they contain (Hourcade, Parette Jr., Boeckmann, & Blum, 2010; Judge, Floyd, & Jeffs, 2008). Hourcade et al. field-tested an emergent literacy technology toolkit in an early

childhood classroom, providing a detailed description and examination of the tools comprising the toolkit (Hourcade, Parette Jr., Boeckmann, & Blum, 2010). In another study that spanned a three-year period, Puckett (2006) compiled and field-tested an assistive technology toolkit and reported the experiences of seventy teachers who used the toolkit for students with learning disabilities, in general classrooms (Puckett, 2006). Puckett found that the majority of teachers in the study had no prior access to, or knowledge of, the assistive technology applications in the toolkit. Moreover, prior to using the technology toolkit many teachers also lacked rudimentary technology skills such as using file management utilities; nonetheless, as teachers gained experience with the technology over time, their classroom use of technology became more sophisticated (Puckett, 2006).

Puckett's study illustrates some common obstacles between students and assistive technology: lack of access to technology in classrooms and inadequately trained teachers unfamiliar with providing AT. The toolkit approach is not a fully developed or comprehensive AT service delivery system; it lacks a framework for considering AT, and implementation guidelines, but when implemented school-wide or district-wide, the toolkit model provides many students with technology interventions and immediate access to the general curriculum, bypassing the delays of a formal evaluation process.

Likewise, the notion of adapting the SETT ideology into a modernized student-centered approach to AT decision-making led to the TEST 'Toolbelt Theory' posited by Ira David Socol (Socol, 2005). TEST combines a reframing of the toolkit concept, and remodeling of the SETT framework, in which SETT is reordered with task-analysis sequentially ranked first as: Task, Environment, Skills, and Tools (Socol, 2005). Unique in the TEST 'Toolbelt' model is it's task-focused and student empowering approach to assistive technology decision-making and intervention. TEST 'Toolbelt' theory addresses some of the shortcomings of traditional assistive technology delivery systems, and promotes student self-determination through opportunities to

make decisions, analyze, choose, and self-select tools for personal technology toolkits (Socol, 2011). Socol (2007) describes it as follows:

> 'Toolbelt Theory' suggests that we must teach our students how to analyze tasks, the task-completion environment, their own skills and capabilities, an appropriate range of available tools… and let them begin to make their own decisions. (paragraph 2)

In this model, TEST begins with analyzing and understanding the specific Task the student must accomplish; the Environments in which the task is performed; followed by the student's Skills and abilities relative to the task; and finally contemplating Tools for the task (Socol, 2007). The selection of tools thus follows a recursive problem-solving process natural to most tool-users. Given a writing assignment, for example, students first examine the teacher's requirements (length, content, criteria), consider the locations (environments) in which the task will be performed (classroom, library, home, group), consider their own skills and abilities (spelling, reading, organization, keyboarding), and finally identify tools that fit the conditions to accomplish the assignment.

The student-focused ideology of 'Toolbelt' theory is designed to foster students' self-determination, by teaching students to analyze, make decisions, and choose from a variety of technologies they know how to use, and that are available and accessible to them (Socol, 2005, 2007, 2008). Examining choices, making decisions, and determining their own actions are experiences that students with disabilities often lack, and yet are key to developing self-sufficiency and self-determination (Hsiao, 2011; Socol, 2008). In order for students to develop independence in choosing and applying technology, they must develop broad knowledge of technology through instruction that incorporates relevant terminology and introduces various forms, features, and ways in which to apply technology (MacArthur, Ferretti, Okolo, & Cavalier, 2001; Socol, 2005, 2007, 2008).

Tools students know how to use, and are prepared to use, comprise their personal 'Toolbelt'; thus the 'Toolbelt' represents the range of technologies students access, explore, and

use, to get work done (Socol, 2008). The ability to effectively match an appropriate tool to a task involves analyzing the task for acceptable criteria, expectations, time, space, materials, and final product (Socol, 2008). In order to learn to independently apply technology in this way, students need instruction that embeds technology operations within academic content (e.g., writing process) (Alper & Raharinirina, 2006; Graham & MacArthur, 1988; MacArthur, Ferretti, Okolo, & Cavalier, 2001; Socol, 2005; Socol, 2011). Socol recommends some guiding principles in teaching students how to use technology: (a) introduce students to technologies within authentic contexts and tasks, (b) allow trial and error learning, and (c) allow individual choice and decision-making (Socol, 2005). These principals are supported by comparable recommendations from studies on writing (Deane et al., 2008; Graham, MacArthur, & Fitzgerald, 2013), characteristics of struggling writers (Graham & Harris, 2005; MacArthur et al., 2001), and writing interventions (Graham, MacArthur, & Fitzgerald, 2013; Peterson-Karlan & Parette, 2007).

A further component of the TEST 'Toolbelt' theory suggests the conceptual reframing of educational technology as a universal learning and performance enhancing nexus for all students (Socol, 2011). Technology implemented school or district wide can furnish tools and options that increase the functional abilities of all students. Combining, rather than partitioning, general and assistive technologies and extending the full range of available technology to all classrooms and across all schools, positions technology to enhance the performance of every student. This model approaches the tenets of Universal Design and serves the widest range of students (Socol, 2006; Socol, 2011). Apart from supplying struggling students (without disabilities) with beneficial technologies, eliminating the distinction between assistive and general education technology has many potential benefits (Socol, 2011). When technology is universally available, students with disabilities are not stigmatized with 'different' materials and are consequently more disposed to using supportive technologies. Universal technology also has financial benefits, as whole-school site licensing is more cost-effective than purchasing single or even multiple copies of programs in the quantities generally needed; and technology

maintenance and support costs are reduced when programs are managed district-wide rather than singularly.

The TEST 'Toolbelt' theory offers a promising alternative service delivery framework for assistive technology; as such, its advantages include a process for considering AT, a student-centered approach that promotes technology skills for a lifetime, and guiding principles for AT implementation. Additionally, 'Toolbelt' ideology promotes universal design principals, which benefits all students, unifying technology for common use and access by everyone.

H. **Problem Statement**

There is ample evidence that technology integrated instruction enhances the educational performance capabilities of students with learning disabilities. Moreover, the existence of federal mandates to consider assistive technology when developing the IEP of every student, intended to ensure meaningful and profitable access to the general curriculum, remains essentially unmet for the largest sub-group of students receiving special education services, those with learning disabilities. Although general education technology has ballooned in recent years, a number of unyielding barriers remain between students with learning disabilities and access to mandated assistive technology. Of the barriers, foremost is a lack of alternatives to current anachronistic AT service delivery methods, which, by ideology, inadvertently underserves a substantial number of students with learning disabilities. Thus, there is a pressing need for appropriate AT service delivery policies and practices that effectively serve all students with disabilities, and include the following new elements: (1) assimilation of universally beneficial AT with general technology made accessible in all classrooms, to all students; (2) implementation strategies for integrating all technology instruction within academic content relative to authentic purposes; (3) implementation guidelines for promoting students' (technology) self-sufficiency and self-determination; and (4) practical methods for incorporating teacher training and support. Reaching and serving the needs of all students with disabilities, particularly the large group of overlooked students with learning disabilities, is of the utmost importance and urgency.

I. Significance of the Study

Literature on alternative AT service delivery systems in education is scarce, and includes more anecdotal and descriptive reports than empirical studies. The few studies that field-tested a technology toolkit method, center on either teachers' reactions to using a toolkit with students in their classroom, or the formation and content of the toolkits. Studies considering student outcomes of either the technology toolkit, or 'Toolbelt' methods were not found in this review of available literature. Research is needed to inform the development of an effective AT delivery methodology that meets all necessary criteria, including practical applicability to classroom environments. Furthermore, implementation studies considering student response and performance outcomes of posited AT delivery methods are needed to gauge the effectiveness of any theorized approaches to addressing the identified gaps in AT services.

This study considered student outcomes from classroom implementation of the technology 'Toolbelt' framework, as a prospective alternative AT service delivery methodology. Classroom implementation of technology was emphasized, guided by general 'Toolbelt' precepts that were developmentally adapted for elementary school students. Studying the effects of implementing an alternative AT delivery approach (the technology 'Toolbelt' model) in whole classroom instruction, will add to the body of knowledge in this area.

J. Purpose of the Study

The purpose of this study was to evaluate writing productivity outcomes and the technology choices of elementary students with learning disabilities from classroom implementation of the technology 'Toolbelt' framework, which included the following components. (1) A broad range of technologies (including assistive technology) was available and accessible to students within the classroom. (2) Technology was embedded in writing curricula that included instruction in both writing processes and how to use the technology. (3) Technology integrated instruction occurred in whole class lessons that incorporated select empirically based teaching recommendations. (4) Lessons were planned and taught

collaboratively by an assistive technology leader and the classroom teacher. The objective was to combine several factors not previously studied and measured, such as implementing the technology 'Toolbelt' theory with elementary students, integrating AT intervention into curriculum and instruction within a classroom, and supplying teacher training and support concurrent with student instruction.

Writing productivity was measured using a paired samples t-test to compare the total number of words written by students during a weekly writing activity. Additionally, teachers observed and tallied the types of tools used by students when technology was utilized in the classroom. Students' writing productivity and the type and frequency of technology use, were used to judge the effects of this alternative AT service delivery methodology.

II. METHODS

A. Conditions

1. Setting

This study took place in a small, public, suburban elementary school, located on the border of metropolitan Chicago, during the special education five-week summer school program. All activities occurred within one, multi-age classroom, with elementary students entering grades four, five, and six. The summer program met Monday through Friday mornings for three hours, or half of a regular school day.

The Internal Review Board for the protection of research subjects determined this study met the criteria for exemption by way of research conducted in an established educational setting, which involved examining the effectiveness of special education instructional strategies. Written information about the study protocol was provided to all subjects' and their families; participation was voluntary, and students or parents could opt-out of the study at any time. The instruction, activities, and materials used in the classroom were applied with all students, regardless of participation in the study; participating students' writing scores, and technology usage was included in the analysis of outcomes. No one elected to opt-out of the study.

Adults in the classroom consisted of the primary classroom teacher, a teacher assistant, and the lead investigator (assistive technology leader). The primary teacher is certified in special education, and works for the school district in which the study occurred, with students similar to those in the study (i.e., attend general education and receive special education support services). Prior to beginning the study, the primary teacher characterized her technology skills as competent to use and support some word processing writing technologies with students, but she had not integrated technology with writing instruction and had limited experience using the writing technologies included in the study. She also expressed interest in learning more about

using technology to support student learning. The role of the teacher assistant was to aid the teacher with classroom tasks, manage materials, and to assist and supervise students. The lead investigator regularly provides assistive technology services, training, and support to teachers and students, using a collaborative co-teaching method to model technology integration in classrooms. All lessons utilized in the study were planned by the lead investigator in consultation with the primary teacher, aligned with the College and Career Readiness anchor standards for writing, and were co-taught as whole-class lessons by the primary teacher and lead investigator.

2. **Students**

Students included in this study satisfied the state and local criteria as having a specific learning disability; all received special education services (through an IEP) to fully access and participate in general education. Furthermore, participants were enrolled and entering grades four through six in a suburban school district, and attended the district's (Special Education) Summer School Program (July-August 2013). The students in this study, all attend general education classrooms during the regular school year, and were recommended for special education summer school because of academic concerns, and to forestall potential skill regression during the summer hiatus. All participating students performed below their grade-level in reading, writing, and math.

One classroom out of twenty summer classrooms met the following criteria and was designated for inclusion in the study: (1) the classroom teacher volunteered to participate and collaborate in the technology-integrated instruction under study, and (2) all students enrolled in the classroom met the above student criteria for inclusion. Summer classrooms of this type vary in size from five to twelve students; eight students were enrolled in the participating classroom. One student attended only three out of five weeks of the program, and was therefore not included in the study. Seven students, three boys and four girls, in the classroom participated in

the study; each of them attended all five weeks, with an average absence of 1.6 out of 25 days (or 94% attendance).

3. **Materials**

The classroom had daily access to enough Netbook (laptop) computers for every student in the classroom, a computer projector, three iPad tablets, and traditional paper materials. A single, shared computer printer was located in the library (approximately 200 feet from the classroom), but was inoperative during most of the summer program. All students had background experience using the Netbook computers for various purposes, including word processing. It should be noted, however, that all students demonstrated poor typing skills, and limited knowledge of keyboard and word processing functions (such as copy and paste, open and save documents, and use of editing tools). This may have been due to age or grade level, but is also fairly representative of the technology skills many students with learning disabilities lack.

B. **Design**

This study was a small group repeated measures intervention in which writing productivity was monitored throughout the summer program. A paired samples *t*-test was used to compare the writing productivity of each student in the first week and last week of the summer program. All students participated in the daily classroom routines, which primarily emphasized reading and math instruction and practice, in addition to thirty to forty-five minutes of (technology integrated) writing instruction and practice. Technology tools were introduced within writing instruction, in daily lessons. Weekly writing probes measuring the number of words written were used to monitor student performance. Additionally, the amount, and kind, of technology used by students over the five-week period was tallied and examined. The number of different technology tools used by all students (combined) was compared each week, and individual tools were appraised for the overall frequency of use over five weeks.

C. **Measures**

1. **Writing productivity**

Measuring writing performance has been an ongoing challenge for educators and researchers, not only regarding what to measure and how to measure it, but also in establishing consistent reliability and validity (Huot, 1990). As such, a degree of variability in writing assessment exists among schools, regions, and states. The curriculum-based measurement (CBM) is one recognized means of sampling and evaluating student performance; popular because it is easy and quick to administer, uses repeated measures derived from curriculum materials, and can provide information about rate of progress and response to instruction (Amato & Watkins, 2009; Hosp, Hosp, & Howell, 2007). Originally used in special education, curriculum-based measurement is sensitive to instruction and meant to detect student response to instruction, within a short period of time (Hosp, Hosp, & Howell, 2007). Studies have found three CBM writing indices to be valid and reliable performance indicators for elementary students: total words written (TWW), total words spelled correctly, and the number of correct word sequences (Amato & Watkins, 2009; Espin, Shin, Deno, Skare, Robinson, & Benner, Identifying Indicators of Written Expression Proficiency for Middle School Students, 2000). These CBM's quantify basic foundational writing skills and fluency, which correspond with the typical emergent skills of elementary student writers (Amato & Watkins, 2009). When students develop more advanced writing skills, usually secondary students, the basic fluency indices (total words written, and words spelled correctly) become insufficient for detecting change, and more sophisticated measures are needed (Amato & Watkins, 2009).

The written expression CBM is typically administered at regular intervals; students are given a writing prompt, or story starter (a topic sentence fragment designed to evoke a broad response), followed by one minute to contemplate what to write, and a fixed amount of time (three to ten minutes) to compose a response (Hosp, Hosp, & Howell, 2007). The completed writing samples are then analyzed and the CBM indicators recorded. Spelling, grammar, and

content are not taken into consideration when counting the total words written (Amato & Watkins, 2009). Accepted words are defined as a group of letters separated by space or punctuation; numerals and symbols are not included in the total (Amato & Watkins, 2009).

Written expression may be evaluated by several characteristics; for this study the total words written (TWW) measure was chosen for the following reasons, (a) it is easily implemented by classroom teachers; (b) it is curriculum centered, thus linked to instructional objectives; (c) it uses criterion-based measures that yield level of performance and rate of progress information (Hosp, Hosp, & Howell, 2007); and (d) the amount written is germane to undeveloped fluency skills common among writers with learning disabilities. As such, written productivity, total words written in particular, was considered likely to be a sensitive indicator of change in the writing performance of emergent and developing writers. Since students with learning disabilities generally struggle with working memory, take more time, and write less than their peers, ten minutes of writing time was allotted for writing probes, to allow enough time to capture adequate student information (Hosp, Hosp, & Howell, 2007).

Initial writing prompt data was collected at the start of the program (day four); final data was recorded in the last week of the program (day twenty-four). The writing prompt (a topic sentence fragment, such as “I looked out my window and to my surprise …”) was given orally and displayed in writing at the front of the classroom. One minute of ‘think’ time was given to consider the prompt and what to write, followed by ten minutes to produce a response. A timer signaled the end of ten minutes, and everyone was reminded to stop writing, and save their electronic file. To maintain consistent assessment conditions, students used the same type of computer (classroom HP Netbooks), and the same word processing program (WriteOnline©) for all writing probes; however, students had the liberty to use any support tools or features available within WriteOnline© or the computer operating system. The classroom teacher scored the writing probes for total words written, and provided this information to the investigator.

2. **Technology tool use trends**

Tuition and access to technology has been shown to improve the performance capabilities of students with learning disabilities. More information is needed to understand how technology adoption and skill acquisition occurs and evolves for students with disabilities. Thus, this study included observation of students' technology use, relative to adoption and usage patterns. Students used technology they had been taught, to complete class work. Teachers recorded observations (of technology used, and number of times in use) daily, on tally sheets. Planned technologies were listed on tally sheets, with space available to write-in unplanned technology spontaneously used by students. These observations yielded information about the number of technology tools used each week (rate of tool acquisition), and the frequency each tool was used (supposed preferences).

D. **Procedures**

1. **Key operational components**

As previously stated, the aim of this study was to examine outcomes of implementing a technology 'Toolbelt' model, in an elementary classroom, as an AT service delivery method. The TEST 'Toolbelt' theory provides an ideological foundation from which to design an AT delivery method that ameliorates critical unmet obligations. This includes, but is not limited to, providing AT to all qualifying students with disabilities, eliminating habitual delays and barriers between students and technology, building technical capacity among teachers, and effectively integrating technology instruction within academic content. These identified AT requirements were addressed in this study through the provision of four key operational components. (1) Establish a broad range of technologies available in all classrooms, and accessible to all students. (2) Use integrated instruction to teach students about various features and ways to apply technology. (3) Create a positive learning environment to foster success. (4) Incorporate productive professional development for teachers.

a. **Make technology available**

During the summer school program an array of technology was available and employed in every classroom with all students. Technology available to the students participating in this study included: eight Netbook laptop computers operating Windows 7 (one per student), three Writers (portable word processors) for keyboarding instruction and practice, three iPad tablets, and a wide range of computer applications. The five-week duration of the program was not enough time to introduce and explore all available computer and tablet applications.

b. **Technology integrated instruction**

While writing instruction was emphasized, various technology tools, specifically identified to support target writing tasks, were also incorporated into whole class lessons and applied to related writing activities. Students wrote daily, for at least 20 minutes, and up to 40 minutes in class. Daily progress monitoring of task and tool performance informed the pace and direction of instruction. Brief instructional units were taught three to five times per week depending on student progress; otherwise previously assigned work was either reviewed or completed. Writing instruction, aligned with College and Career Readiness (CCR) anchor standards for writing, focused on specific sub-components of the writing process (plan, draft, revise), and incorporated modeling of task-supported technology. A projector displayed the teacher's Netbook computer on a screen for students to observe and emulate on their own computers. Lessons followed a general sequence, beginning by stating the writing goal, then explaining and modeling the targeted text structure or writing framework, using computer tools to produce the composition. These lessons were intentionally brief (10 minutes) to encourage student engagement and participation. Technology instruction included operation and application skills, technical terminology (e.g., toolbar, user preferences), modeling of independent problem solving ("I'm not sure, but I can check the options in this menu"), and collaborative (group) problem solving. Natural opportunities were used to indicate or reinforce

technology skills during writing instruction; for example after discussing and composing a topic sentence, a teacher may say, “I should save my work now”, and model the saving process.

Though instruction was planned around strategic lessons, two factors influenced the selection and sequence in which technology tools were introduced. First, more time was occasionally needed to achieve target performance levels in curriculum and instructional goals. Secondly, during the first seven days of the summer program there were relentless problems with the students’ computers, including batteries not maintaining a charge, critical operating system updates needed, web browsers not supporting necessary programs, and Internet connection disruptions. Technology problems are not unusual, but can delay instruction and student progress when they occur. All of the technology issues were either resolved, or accommodated within the second week.

c. **Positive learning conditions**

The development of self-reliance, and ultimately self-determination, is vital to all students, but particularly crucial for students with learning disabilities who must become advocates for themselves, and for the accommodations they require. Teaching students independence and self-actualization is a cornerstone of the TEST ‘Toolbelt’ model; altogether lacking in previous AT service delivery models, mechanisms for fostering self-sufficiency are paramount to new AT provision constructs. Promoting independence and confidence were thought to be appropriate objectives for the elementary grade level and emergent abilities of the students in this study. Establishing positive learning conditions in the classroom using guiding principles from the TEST ‘Toolbelt’ and explicit instruction models addressed this. A positive and successful learning environment was established in the classroom using the following strategies: allow sufficient time for instruction and learning (observe student performance, not timetables), encourage a high degree of student participation, create opportunities for student choice and decision-making, monitor performance continually and give frequent reinforcement, recognize and reinforce desirable behaviors,

promote frequent peer collaboration (learning, problem solving, sharing), and allow trial and error exploratory learning. Finally, student participation was always favorably acknowledged, including reacting positively to incorrect answers. For example, rather than indicating, “no, that’s not right”, a teacher might respond, “that’s a really good clue”, or “that’s interesting, I’ve never thought of that”. Praise and feeling valued and successful is particularly important to students with learning disabilities who are more often prone to wrong answers and low scores; they become discouraged, reducing their participation and ultimately their interest in school.

d. **Professional development and support**

Reaching and serving the AT needs of all students with disabilities in their classrooms compels a degree of technology proficiency in those who instruct and engage the majority of students’ time, their classroom teachers. Nonetheless, adding professional development time to the school day, or removing teachers from classrooms for training is impractical and ineffective. The necessity of including training and support for teachers in particular, but also for students, is critical to any assistive technology service delivery model, and was considered a crucial element of this study. Training and support requirements were thus managed by involving the assistive technology leader (lead investigator) in classroom instruction. To maximize potential benefits, considering the five-week time constraint, AT classroom collaboration and co-teaching occurred daily. The lead investigator planned and co-taught specific technology integrated writing lessons with the teacher, modeling and guiding progressive technology skill development. The teacher was supported using a hybrid of training approaches, consisting of collaboration (lesson planning, progress monitoring, and classroom management), modeling (demonstrating technology operation and integrated instruction), and shared teaching. Students were supported in their natural classroom environment, where they might benefit from relevant ongoing AT assessment, monitoring and modifying AT interventions and strategies, meaningful immediate technology assistance, and increased instruction and access to various technologies.

2. **Lesson plans and instructional strategies**

Lesson plans included three key concepts: (1) model technology in context with writing instruction, focusing on the processes of planning, transcription, and revising; (2) provide enough support for learning while enabling students to discover things on their own (heuristic learning); (3) encourage student success through goal setting, praise, and interaction with each other; and (4) allow students to make choices and decisions. Writing activities included recursive writing process strategies, and descriptive narrative development; laptop computers containing writing tools, were in the classroom and used every day. To reduce potential frustration, foster success, and thus maintain student engagement in the writing assignments, longer writing processes were separated into smaller steps, setting short-term goals created a feeling of accomplishment (e.g., “list three main ideas about your topic”), and flexible lesson plans allowed teachers to accommodate students’ interests.

a. **Week 1 poetry and word processing**

The first lesson was designed to be simple and engaging in order to convey the likelihood of success and encourage participation. It was also used to evaluate students’ abilities and skills, since all students were able to do the assignment.

Students were introduced to the poem “Tell Me” (Silverstein, 1996); the class discussed the simple light verse, expressed opinions, and discussed descriptive adjectives. The assignment was to rewrite the poem, substituting the adjectives with personally significant replacements. A teacher modeled the assignment, using the target technology; concurrently students participated by suggesting adjectives, and providing technology information when prompted (e.g., “how would I open a new document?”).

Technology introduced in this activity included WriteOnline© (web-based word processing), and the following WriteOnline© tools: word prediction, and text-to-speech. Basic technology skills, including simple navigation, saving, and locating saved files required instruction and practice. Students used word prediction to expand their descriptive word

choices, and text-to-speech to judge how their writing sounded. Listening to the text helped some students identify ways improve their writing. This project required the entire first week because technical problems reduced access to computers and caused delays in completing the assignment.

b. **Week 2 planning and graphic organizer**

Students were taught planning strategies with a graphic organizer for a short fictional narrative. The assignment was to think of ideas and organize them into an electronic graphic organizer. The activity was too difficult at first, and the students struggled, quickly leading to frustration. When this was apparent, the assignment was modified into a smaller sub-task.

The writing task was modified to planning just three main events for a fictional narrative (beginning, middle, and end), creating an electronic graphic organizer and placing the ideas in sequence on the graphic organizer. Teachers assisted the students with technical questions, as well as encouraging peer assistance and collaboration.

Technology used: WriteOnline's Workspace (graphic organizer tool) was introduced in this activity. Reviewed technology included word prediction and text-to-speech, which students applied with improving fluency.

Students enjoyed the writing assignment and the planning task using the graphic organizer tool, once it was divided into smaller, more manageable parts.

c. **Week 3 begin a narrative – apply technologies**

Mid-way through the five-week program, the students became somewhat listless, and less enthusiastic about writing. To prepare them to write a fictional narrative, and spend time focusing on writing process and strategies, the class watched and discussed a YouTube© video, "A Day In The Life Of A Bookbag" (Autio & Foreman, 2013).

The student-made video was about a typical day in the life of a student's book bag, and it prompted a dialog. The class discussed what they liked and didn't like about the scenario and

how it was depicted, ending in unanimous agreement that they could all write a better version. Thus, the student-sanctioned long-term assignment was to write a story about a day in the life of an inanimate object. Tasks were divided into short-term goals beginning with choosing an object to write about and generating some ideas, then planning, sequencing, and drafting a story.

The technology tools introduced over the previous two weeks were reviewed briefly, and students selected their own tools to work on the assignment. Instruction focused on reinforcing the recursive writing process, strategies to enhance descriptions, and narrative style. During the third week, applying technology to write was becoming routine and more fluent.

d. **Week 4 from revisions to storyboards**

Students continued to work on composing their fictional narratives ("A day in the life of _"), and by the fourth week they were at various stages of writing. Some were beginning to transition from organizer to first draft, some had completed their draft, and one or two were still working on the planning stage. The beginning of the week was spent writing, and advancing through the sub-divided process of composing.

Mid-week the students were introduced to editing and revision strategies in small groups. Technology to support editing and revision included spell check, the 'Find' tool, word prediction to expand vocabulary and detail, and text-to-speech to listen for clarity and errors. When the students lost interest and became less productive with the editing and revision tasks, another modification was quickly made to recapture their interest.

An idea to convert the stories into screenplays and videotape them was eagerly embraced by all students. Students were given the option to choose one or two stories to adapt collaboratively, but everyone wanted to adapt their own story. Converting the stories into screenplays was another, more exciting, form of reviewing, revising and editing. Paper storyboard planners were introduced in the last two days of the week. The assignment was to sequence and plan video images representing the main elements of the stories, which generated a high degree of student engagement and productivity.

e. **Week 5 video representation of writing - filming**

While students finalized their storyboards and prepared for their video productions, daily writing tasks continued in various forms: job lists and assignments, props lists, and timelines for videotaping. Technology applied during this week consisted primarily of the iPad tablet, used for video capture, and some iPad effects.

The final assignment was again divided into a series of small manageable tasks, most of which required a considerable amount of collaboration and coordination among the students. Students produced their own stories, beginning with recruiting their crew: a camera operator, actors, and director. They also arranged their rehearsals, divided and shared classroom space, assisted each other with props, and carried out the filming, with minimal guidance. These tasks were challenging and demanding; yet all students were highly engaged and self-sufficient.

All filming was completed before the last day, which did not allow for student editing. The AT leader (lead investigator) compiled and prepared the video footage for a student film festival of their work, shown on the last day of the program.

II. RESULTS

A. **Written Productivity Outcome**

Each student's writing scores (number of words written) increased from the first week of the program compared to the fifth week (Table I). The difference in the scores averaged across all students is significant, using a paired samples *t*-test. The increase in the number of words written across students (shown in Figure 2) was statistically significant ($t = 5.78$, $df = 6$, $p < .001$). The largest difference in the number of words written between the first and fifth weeks was 70 words, the smallest difference was 21 words, and the average difference in words written was 51 words. These results suggest that students' wrote significantly more after 5 weeks, than they did at the start of summer school.

TABLE 1

COMPARRISON OF EACH STUDENTS' NUMBER OF WORDS WRITTEN PRE- AND POST INTERVENTION

Student	Week 1	Week 5
1A	26	88
2J	23	89
3K	5	55
4N	49	70
5E	15	85
6Z	29	84
7T	7	40
Average	22	73
SD	15	19

Every participant in the study increased written productivity, as measured by number of words written.

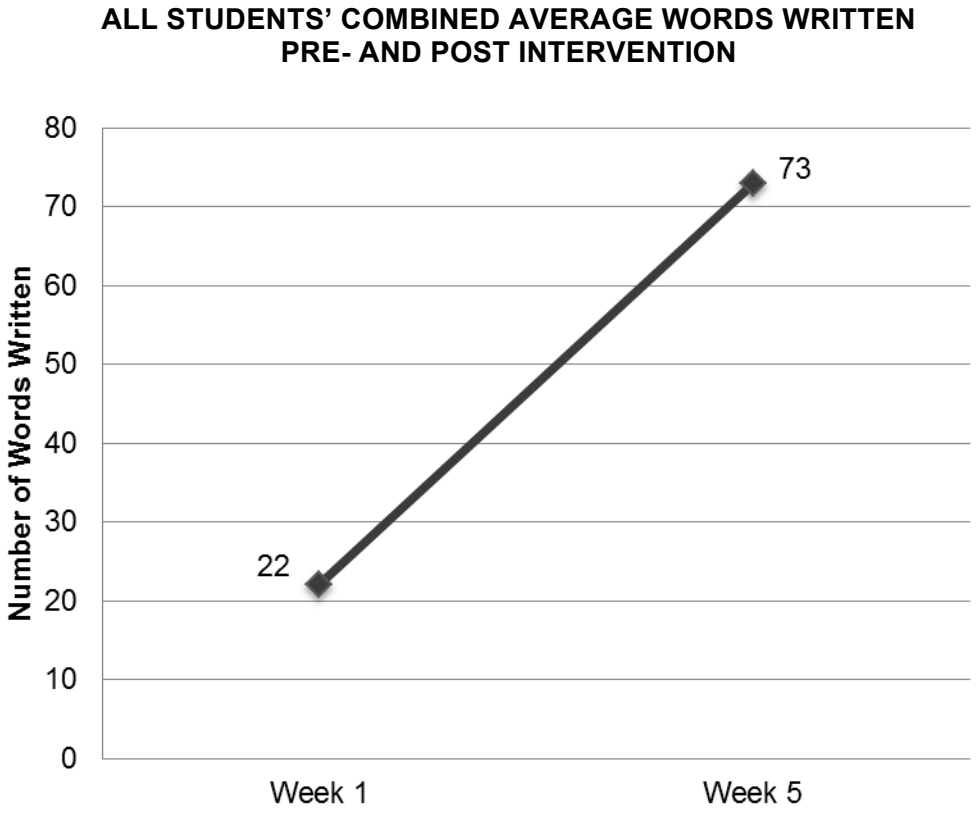

Figure 2: The increase in the average number of words written, across seven students, over five weeks, was significant (t = 5.78, df = 6, p < .001).

B. **Technology tool use outcome**

Students' technology tool use increased evenly from the first week through the fourth week, correlating with the addition of new tools while concurrently retaining previous tools; but then reduced slightly from week four to week five (shown in Figure 3). The decline between weeks four and five may be attributed to a shift in classroom activities from text production to multi-media rendition. Moreover technology usage patterns appeared to match students' work requirements, such that task demands appeared to influence tool use.

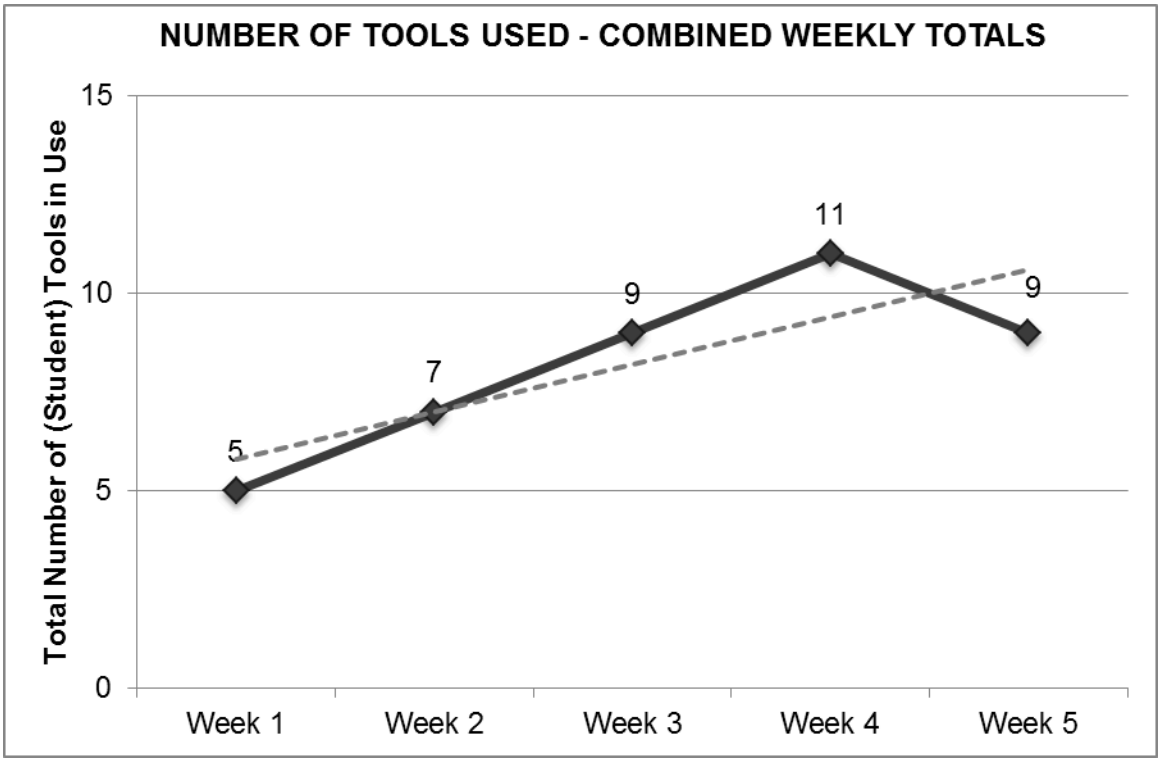

Figure 3: The number of technology tools students' used in the classroom increased overall, and correlated with students' task demands.

The technology tools introduced during the study were compared for the frequency with which all students (combined) used each tool. Figure 4 shows the number of times various tools were used by the students throughout the five-week program. The highest rates of use were seen with text-to-speech, and word prediction (text-to-speech and word prediction are features within WriteOnline©). Technology occurrence rates that exceeded one use per student, per day, resulted from students who began using the technologies multiple times per day, for class work in other subjects, particularly for writing tasks.

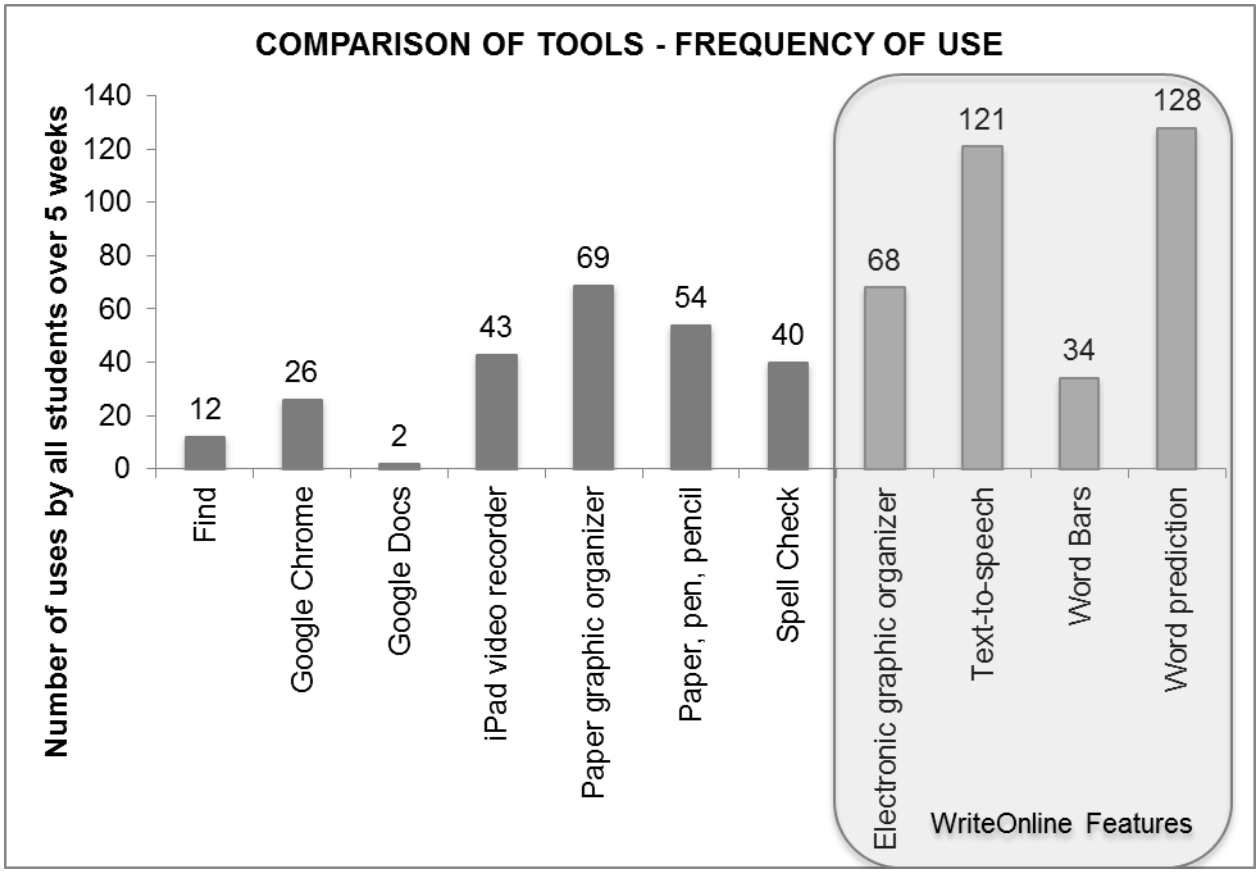

Figure 4: Comparison of technology tools by frequency of use during the five-week program.

III. DISCUSSION

The alternative assistive technology service delivery model postulated in this study is an emerging concept derived principally from technology 'Toolbelt' theory, conceived with the goal of improving AT service delivery to students with disabilities in schools. Implementation in a small classroom, over five weeks, successfully fulfilled key operational objectives.

Establishing a broad range of technologies, available in every classroom to all students, requires the planning and commitment of school districts to offer instructionally accessible classrooms. There are many low cost, and no-cost ways for schools to begin, although doing so requires excellent communication and collaboration between technology, instructional, and special education departments. The school district in which this study occurred has offered a wide range of accessible, assistive, and universally beneficial technologies in every classroom, to every student, for the past decade. Thus this particular component was in place prior to, and during, the study.

Through the inclusion of an assistive technology specialist in the classroom as a teacher collaborator, technology knowledge and skills may be effectively transferred from 'experts' into classrooms where it is needed. Integrating technology with content area instruction, teaching students about technology features and capabilities, and effectively supporting a variety of technology tools was accomplished in this model through concentrated collaboration, lesson planning, progress monitoring, and co-teaching. These same activities also provided meaningful and relevant professional development for the teacher, as well as direct AT assessment and support to students. Creating a flexible, positive learning environment was possible, again through planning and collaboration in the classroom. This model was also successful in providing all of the students in the classroom with access to assistive technology. These students were typical of many other children with learning disabilities, in that they are routinely overlooked or not considered for assistive technology. While a student's IEP may

target the planning, transcription, and revision process, assistive technology tools supporting these procedures are habitually nonexistent for students with learning disabilities. The persistent, prevailing assumption seems to be that assistive technology is for children with more significant or obvious disabilities.

The participating teacher was experienced and comfortable teaching process, strategy, genre, and literary aspects of writing, but not familiar or comfortable teaching with technology. By the end of five weeks, the classroom teacher enthusiastically related her plans to incorporate technology with all of her students in the coming school year, and her confidence in her ability to do so.

A. **Improving Written Productivity**

Improvements in student writing support the type of instruction and model of assistive technology provision posited in this study. Students in the study wrote significantly longer compositions after five weeks of technology-integrated writing instruction, than they did in the first week of summer school.

There are a number of factors that may account for the progress students made. First, students simply had opportunities to write every day. This finding would support researchers' recommendations that students spend more time writing. Another possible explanation is that students had daily access to technology for writing, which has also been established in the research; students tend to write more when they apply technology they have been taught to use. Writing with computers for five weeks may also have produced a practice effect, or simply skill development, to explain the increased productivity. Additionally, students were taught to use assistive tools to augment disability-related limitations, and any one, or all of these tools may have contributed or produced the improvement. In the few studies available on assistive technology outcomes, research indicates positive outcomes for individuals using assistive technology.

Writers with learning disabilities tend to lack a writing procedure, which was addressed in this study by providing direct instruction in process-oriented writing; thus explicit writing instruction may also account for the improvements the students made. This is, again, consistent with research on interventions for students with learning disabilities, since writing instruction has been shown to improve writing. Finally, the proposed intervention, which was to integrate all the methods just described (research-based writing instruction with universal technologies and assistive technologies) as a collective approach for the classroom, may account for the improvement in written productivity.

The task of writing requires the complex, simultaneous balance of skills, concentration, and physical execution; it follows that the intervention should undertake multiple deficit areas concurrently. Such an integrated methodology may be a means to serve a greater number of students together, since integrated methods inherently provide multiple support variations, which may serve students with a wide range of educational needs.

More research is needed to determine if this method can broaden the educational support students with learning disabilities receive, and if doing so consequently improves academic achievement among students with learning disabilities.

B. **Technology Tools and Proficiency**

This study also considered the types of technology, and the total number of tools used by students each week. For the number of tools used, the results show a gradual increase in technology tool use that was highest in the fourth week. This outcome is consistent with the classroom activities occurring each week. Technical problems may account for the small number of tools used in the first week. The second and third weeks show slight increases that are consistent with the pace new tools were introduced; it may be inferred that students retained tools introduced in previous weeks, thereby adding to their personal technology 'Toolbelts'. The highest number of tool use occurred in week four, again consistent with the writing activities and

tools taught and modeled. The decrease in week five is slight, and can be attributed to the alteration in activities from text production, to recording video.

While this information indicates students were using technology tools appropriate for their tasks, it is most likely because students were guided by teacher instruction and technology modeling during writing lessons. Students may not have been independently selecting technology, but they did seem to respond to instruction and modeling, as evidenced by their tool selections. It is doubtful that the students developed the ability to independently select tools without a teacher-model, given the short duration of the program. In fact, students may be habituated to continual guidance and direction, so that they resist independent choices, and seek reassurance, even when they know what to do. For example, some students asked to be told the next step in a technology sequence, yet when prompted, “show me what you think you do next”, students most always knew what to do. In the five-week program, all students learned to use new technology tools at varying levels of proficiency, all achieved operational competency (learned to use), and many students approached, or achieved, functional competency (apply to accomplish a task).

Once students develop basic requisite skills: understand the task and know how to use technology tools, with access to technology, they may begin to exercise technology autonomy.

Finally, a few of the technology tools that students’ used to accomplish class work were used with much greater frequency compared to the other tools. It should be noted that included in the comparison were two tools that were not integrated with lessons, but which students used on their own (including paper and pencil). A comparison of eleven tools, introduced to all students or self-selected by some students, across five weeks, ranked by number of times used, resulted in the following order (most to least used): 1) word prediction (component of WriteOnline©); 2) text-to-speech (component of WriteOnline©); 3) paper graphic organizer (Storyboard); 4) electronic graphic organizer (component of WriteOnline©); 5) paper and pencil;

6) iPad video recorder; 7) spell check; 8) Wordbars (component of WriteOnline©); 9) Google Chrome web browser; 10) 'Find' feature; and 11) Google Docs (word processor).

WriteOnline© word processing was used most, which correlates to both the classroom activities and the technology modeled with writing instruction. The low frequency of tool use for editing (spell and grammar check) is consistent with research studies that have found students with learning disabilities lack intrinsic steps or strategies for carrying out editing and revision. Then again, lower tool usage may relate more to the amount of time spent on editing instruction and tool modeling within instruction. In fact, research identified the same lack of strategy or process skills for planning and organizing, yet in this study, the organization tools were used twice as often as editing tools. This lends support for the argument that student performance correlates to the amount of technology modeled with instruction, as more time (three weeks) was spent on instruction and practice for the planning process of writing, while editing instruction was limited to a few days. Rather than pursue a fixed lesson timeline, the classroom environment was intentionally flexible and (student) success oriented, thus writing process concepts were extended as long as students remained engaged and demonstrated progress. Other factors governing instructional plans included technical equipment obstacles, and other classroom event requirements. Students in the study appeared to use technology tools in proportion to the amount of instruction and guidance they received. This idea is further endorsed by the low frequency of use for the other tools ('Find', Wordbars, Google Chrome), which were also used relative to the amount of time the tools were modeled with instruction.

These results suggest that: 1) students in upper elementary grades respond to technology modeling integrated with instruction, by emulating the teacher and using the same tools; and 2) new technology adoption may be directly proportional to the amount or degree of instruction time; the more time technology is integrated with instruction and practice, the more likely younger students are to apply new technology.

C. **Limitations**

This study was a “test of concept” effort that measured the written productivity (number of words written), in one group of multi-aged students with learning disabilities, in one classroom, over a five-week period. The lack of a comparable classroom to serve as a control group is a limitation of this study. Given the cluster methodology of the intervention, multiple control groups are needed to control for extraneous variables and variations. A single control group that receives regular instruction with standard technology would leave a number of non-controlled variables such as process-focused instruction with technology modeling, research-based instructional guidelines, heuristic learning model, and assistive technologies are a few potential variables. To measure the impact of each variable, compared to the integrated model, would require several groups to isolate each variable. While the lack of standardization is a clear limitation, using a control group or multiple groups, would be a difficult endeavor to undertake in school classrooms. Although this study established the effectiveness of this model of assistive technology delivery, it is impossible to know exactly which variables account for the outcomes.

Adding more subjects or groups would strengthen the sensitivity of the study and allow more carefully constructed controls receiving the same integrated intervention. Finally, adding other written expression measures may strengthen a study like this, such as words spelled correctly, and correct word sequences, both of which are Curriculum Based Measures that have demonstrated reliability and validity.

This study was conducted with elementary school-aged students with specific learning disabilities (as defined in IDEA); the results are generalizable only to students within the same age and disability group. A larger study, involving more subjects, over a longer period is needed to confirm these results. To generalize the results to other grades, or ages, a study with other grade-levels is needed.

D. **Educational Implications**

This study yields several implications for school districts, students, and teachers. First, for technology to be an effective tool, classrooms need operational and reliable technology hardware, and infrastructure (technology support, reliable Internet connections, and management systems). Due to the rapid growth and mutation of technologies in general, many school districts and school buildings continue to struggle to grasp staffing and economic requirements of managing technology infrastructure effectively. However, for students with disabilities especially, access to good technology is essential to academic survival. In this study students' academic and technology skills improved with consistent access to reliable technology; thus classrooms need enough technology for every student, every day. Finally, technology evolves constantly; schools need flexible technology structures, including mechanisms for routinely refreshing and updating technology equipment.

Students need to apply technology tools to authentic and relevant purposes, every day. To effectively use technology, students must be taught what it can do, and how and when to use it. Younger writers generally have less experience with both the writing process and technology tools that support writing. In order for them to become independent technology 'Toolbelt' wielding tool-users, these students need to understand their tasks well enough to analyze what tools to use. In this study, students benefited from focused writing instruction, peer collaboration, and a mixed guided experimental approach to learning about technology. Students need regular opportunities to experiment and persist in working through problems, build self-confidence, and discover solutions on their own.

Finally, teachers need be prepared to use and integrate technology with instruction, and they need the professional freedom to make modifications to lessons, to adjust to student performance, or enhance student engagement. Teachers need adequate technology skills to guide student learning, and respond to manageable technology issues that arise. Problems with technology in the classroom will inevitably occur, thus basic technology troubleshooting skills

are vital to preventing delays and loss of instruction time. The shortage of technology knowledgeable teachers manifests as a barrier (among several) between students with learning disabilities and access to technology. Daily classroom duties and responsibility for a large number of students, leaves little time for professional development. The usual delivery of information from a knowledgeable expert, although standard practice has not proven useful to most teachers. Training and support requirements were managed in this study by involving the assistive technology leader (lead investigator) in classroom instruction. AT classroom collaboration and co-teaching was successful in building the teacher's skills, as well as simultaneously supporting all students in the classroom. Ultimately training and support will benefit students; investing in meaningful teacher training improves academic potential for all students.

E. **Future Work and Research**

In addition to the ways, proposed above, to improve and expand upon this study, more research is needed to identify best practices in technology-integrated instruction, including how students' needs differ between age and grade levels. And other inquiries are needed to investigate how many and how effectively all children with learning disabilities are receiving the services and supports they are guaranteed under the IDEA. How can the needs of all students with learning disabilities be better and more thoroughly addressed in school settings? And what is the best way to prepare students, from an early age, to become strategic technology tool users?

Considering the vast landscape of modern technology available, this study looked at a tiny sliver of the available electronic resources, tools, and means for creating text, and other forms of expression, composition, creativity, information recording, and authoring. Studies are needed to investigate the potential merits of twenty-first-century digital technologies in education. A new array of technologies is remodeling the form and meaning of writing; electronic, or digital, text can be composed a multitude of ways, using tools as unexpected as a

cell phone. Compared to traditional text, which is one-dimensional and static; digital text is non-linear and includes interactive elements such as hyperlinks, video, audio and images. Digital text is mutable; since electronic text is flexible and malleable, writers can continuously change, add, extract, and revise content. The products of writing are not limited to books, stories, articles, and similar traditional text structures; digital writing includes new forms that vary in length, style, and conventions, and the creation of digital media such as digital video and podcasts. Writing in education has been slow to part with tradition, yet digital writing is gradually penetrating curriculum and instruction. Students with learning disabilities may be the beneficiaries in this revolution; they may find that digital writing is a more natural way for them to construct text, express information, or illustrate ideas, and more representative of their abilities and knowledge. Research must extend to consider ways in which digital writing, with its unique tools and conventions, may impact academic performance in students with learning disabilities. Digital writing, and its assortment of tools, will surely become a fixture in the personal "Toolbelts" of students.

APPENDIX

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Exemption Granted

July 22, 2013

Sheri Lenzo, BS
Disability and Human Development
313 N. Kenilworth Avenue
Oak Park, IL 60302
Phone: (708) 217-9211

RE: Research Protocol # 2013-0642
"Writing Productivity Outcomes For Students with Learning Disabilities After Technology Instruction Using The Toolbelt Method"

Sponsors: None

Dear Ms. Lenzo:

Your Claim of Exemption was reviewed on July 22, 2013 and it was determined that your research meets the criteria for exemption. You may now begin your research.

Exemption Period: **July 22, 2013 – July 22, 2013**
Lead Performance Site(s): UIC
Other Site(s): Oak Park School District 97
Subject Population: District 97 students (11 – 14 years)
Number of Subjects: 20

The specific exemption category under 45 CFR 46.101(b) is:
(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Please note the Review History of this submission:

Receipt	Submission Type	Review	Review	Review Action

Date		Process	Date	
06/20/2013	Initial Review	Exempt	06/30/2013	Modifications Required
07/16/2013	Response to Modifications	Exempt	07/22/2013	Approved

You are reminded that investigators whose research involving human subjects is determined to be exempt from the federal regulations for the protection of human subjects still have responsibilities for the ethical conduct of the research under state law and UIC policy. Please be aware of the following UIC policies and responsibilities for investigators:

1. Amendments You are responsible for reporting any amendments to your research protocol that may affect the determination of the exemption and may result in your research no longer being eligible for the exemption that has been granted.
2. Record Keeping You are responsible for maintaining a copy all research related records in a secure location in the event future verification is necessary, at a minimum these documents include: the research protocol, the claim of exemption application, all questionnaires, survey instruments, interview questions and/or data collection instruments associated with this research protocol, recruiting or advertising materials, any consent forms or information sheets given to subjects, or any other pertinent documents.
3. Final Report When you have completed work on your research protocol, you should submit a final report to the Office for Protection of Research Subjects (OPRS).
4. Information for Human Subjects UIC Policy requires investigators to provide information about the research protocol to subjects and to obtain their permission prior to their participating in the research. The information about the research protocol should be presented to subjects in writing or orally from a written script. When appropriate, the following information must be provided to all research subjects participating in exempt studies:
   a. The researchers affiliation; UIC, JBVMAC or other institutions,
   b. The purpose of the research,
   c. The extent of the subject's involvement and an explanation of the procedures to be followed,
   d. Whether the information being collected will be used for any purposes other than the proposed research,
   e. A description of the procedures to protect the privacy of subjects and the confidentiality of the research information and data,
   f. Description of any reasonable foreseeable risks,
   g. Description of anticipated benefit,
   h. A statement that participation is voluntary and subjects can refuse to participate or can stop at any time,
   i. A statement that the researcher is available to answer any questions that the subject may have and which includes the name and phone number of the investigator(s).
   j. A statement that the UIC IRB/OPRS or JBVMAC Patient Advocate Office is available if there are questions about subject's rights, which includes the appropriate phone numbers.

Please be sure to:

→ Use your research protocol number (2013-0642) on any documents or correspondence with the IRB concerning your research protocol.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact the OPRS office at (312) 996-1711 or me at (312) 355-2908. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Charles W. Hoehne
Assistant Director
Office for the Protection of Research Subjects

cc: Tamar Heller, Disability and Human Development, M/C 626
Kathy Hooyenga, Applied Health Sciences, M/C 726

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VITA

NAME:	Sheri Barham Lenzo
EDUCATION:	M.S., Disability and Human Development, University of Illinois at Chicago, Chicago, IL, expected 2014
	B.S., Physical Therapy, California State University Long Beach, Long Beach, CA 1982
TEACHING:	Department of Disability and Human Development, University of Illinois at Chicago, Guest Lecture; The 21st Century Toolkit: A Delivery Model for Assistive Technology, 2013
	Department of Disability and Human Development, University of Illinois at Chicago, Guest Lecture; The Technology Toolkit: A Delivery Model for Assistive Technology, 2012
PROFESSIONAL MEMBERSHIP:	The Council for Exceptional Children