Examining the Impact of Technology on Primary Students' Revision of Written Work

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-To my former students, who inspired me to question,
and my son, who inspires me to learn.

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LIST OF ABBREVIATIONS

CCSS – Common Core State Standards

CDO – Compare, Diagnose, and Operate

LD – Lexical Density

LTM – Long Term Memory

NAEP – National Assessment of Educational Progress

NCES – National Center for Education Statistics

NRS – Narrative Rubric Score

PARCC – Partnership for Assessment of Readiness for College and Careers

PWSC – Percent of Words Spelled Correctly

SBAC – SMARTER Balanced Assessment Consort

WC – Word Count

WM – Working Memory

WRAT4 – Wide Range Achievement Test 4th Edition in this research specifically the Spelling Assessment

WWYR – Writing What You Read Rubric from Gearhart, Herman, Novak, Wolf, & Abedi, 1994

SUMMARY

Writing is a complex cognitive task that requires the orchestration of myriad skills. Few studies have examined the revision processes of second grade students and even fewer have explored the impact of digital writing on young students' revisions. The increase in the use of digital assessments to evaluate students writing ability make understanding the impact of digital writing on students' writing processes imperative.

This study utilized a within subject crossover trial using randomized block assignment (AB | BA) for counterbalancing. This study sought to determine (1) whether revising on paper versus revising on the computer significantly impacted revisions second graders made; (2) whether revising on paper verses the computer affected the change in quality from the first to final draft; (3) whether the cognitive load of transcription, writing speed and spelling ability affected the revisions second graders make when revising on paper and the computer; and (4) whether the cognitive load of transcription affected the change in quality scores when students revise on paper and the computer. 74 second graders from a middle class suburb participated in the study. Students received training on how to use the computer to type and edit texts and completed cognitive load measures on paper and the computer for writing speed and spelling ability. Each of the four classes was assigned to one of two conditions: paper revision, then computer revision or computer revision, then paper revision. Students wrote and revised two stories.

Analyses revealed that second grade students made twice the number of revisions on computer than on paper. Across mediums, students primarily made low-level revisions: additions, substitutions, and deletions. When revising on paper, the most common type of revision was addition, while on the computer substitutions were more common. The majority of

computer revisions were changes to spelling, while on paper students made more changes to text organization and semantics. Another interesting finding was the majority of students added on to the end of their stories when revising in both mediums.

Analyses of quality indicators determined that students increased word count in both mediums, with a greater increase when revising on paper. Lexical density was identified as a problematic indicator, as these scores decreased in both mediums. Percent of words spelled correctly increased in both mediums, with a greater increase on the computer likely due to the availability of spell check. There was less observed improvement in narrative rubric scores, but these scores improved more on paper than the computer.

Cognitive load measures indicated a typing was significantly slower than handwriting, but spelling ability significantly increased on the computer over handwriting. These findings supported previous research. First, the lower cognitive load of writing, with respect to writing speed, lead to a greater increase in word count when revising on paper. Second, the decreased cognitive load of spelling on the computer lead to a greater increase in percent of words spelled correctly on the computer and a higher number of spelling revisions.

Overall this study determined that second graders were able to effectively revise texts using paper and the computer. The computer proved to support students spelling resulting in an increase in the number of revisions and the percent of words spelled correctly. Computers can be a beneficial writing tool for second grade students.

"Writing today is not a frill for the few, but an essential skill for the many."

-National Commission on Writing, 2003

CHAPTER I: INTRODUCTION

Writing is power – the power to communicate, the power to change things, and the power to be heard. In today's increasingly global society, the ability to effectively communicate ideas is essential to becoming highly successful. Strong writing skills are a requirement for all professional jobs (National Commission on Writing, 2004). Rising literacy demands require students to be not only critical consumers of information, but effective producers of meaningful texts (Labbo, Reinking, & McKenna, 1998). Writing is not easy; it can take as long as 20 years to become an expert writer (Kellogg, 2008). By preparing students to be effective producers of texts and expressing their ideas, educators empower them to be heard and to fully participate in society.

Writing requires the orchestration of myriad skills, from how to write a story to how to spell a word (McCutchen, 2006). Setting goals, planning, idea generating, transcribing, and revising place heavy demands on cognitive resources (Hayes & Berninger, 2010). These cognitive demands of writing can limit the abilities of novice writers, leaving few resources available for planning or revising texts (Bereiter & Scardamalia, 1987; Kellogg, 2008; McCutchen, 1996, 2000, 2006). The cognitive load of transcription is particularly high for novice writers (Berninger & Swanson, 1994; Graham & Harris, 2000a) Spelling words and forming letters, quickly and accurately, taxes their limited cognitive resources.

Technology brings both new affordances and new challenges for young writers. Computers provide their users with unlimited space, copy and paste functions, spell check, and

the ability to make revisions without having to recopy (Daiute & Kruidenier, 1985; Daiute, 1983; MacArthur, 2006; MacArthur & Graham, 1996). Technology also decreases the importance of two skills previously essential to writing: penmanship and spelling. At least 41 states no longer require schools to teach cursive (Amos, 2013). Instead, states like Illinois and Hawaii have shifted their educational focus to keyboarding skills (Bock, 2012; Huffington Post, 2011; Kaiser, 2011). The shift within society to typing and away from cursive and penmanship makes research on the impact of technology and the writing process critical. Technology significantly affects how students can revise texts by allowing the user to move blocks of text and providing tools like spell check that enhance the readability of their writing (Grejda & Hannafin, 1992; Joram, Woodruff, Bryson, & Lindsay, 1992). Additionally, elementary school students' typing speed is slower than they are able to handwrite, which decreases the quality of writing (Connelly, Gee, & Walsh, 2007).

The global, multicultural, technological world of today already requires high levels of literacy expertise (The New London Group, 1996). As technology continues to evolve, potential challenges students in today's classrooms may face are limitless. Tools and techniques that, decades ago, may have been imagined in only the pages of science fiction are now commonplace. Educators must prepare students to be lifelong learners capable of navigating the information age (Hedberg & Brudvik, 2008). As a result of new and emerging information technology tools have made writing and effective communication arguably more important than it has been in any other period in history. From the beginning of human time to 2003, five exabytes of data were created; today the same amount of information is created every two days (King, 2011). New technologies allow for the production of seemingly unlimited amounts of data and information (King, 2011). Students in today's classrooms need the skills required to

successfully harness the power of the endless streams of data, using writing to analyze and communicate (The New London Group, 1996).

This dissertation will help answer the call from the Common Core State Standards specifically addressing the importance of writing fluency, technology, and revision in their description of a college and career ready student (Council of Chief State School Officers & National Governors Association, 2014). These skills are not developed only in high school classrooms; their foundation is laid in elementary school classrooms across the country. This study explores the impact of the cognitive load of transcription, with regards to writing speed and spelling ability, on the revisions of second grade students using two mediums – paper and pencil and a word processing program. This chapter will explain the need for this research. First, this chapter provides a discussion about writing achievement in America. Then, the chapter provides a description of the Common Core Standards and the rise digital assessments. After that, an explanation of the cognitive demands of writing is given, specifically addressing revision and how students' learn to write. Finally, the chapter ends with a description of the study.

What We Know About Writing Achievement in America

The gold standard in assessment is the National Assessment of Educational Progress (NAEP). The NAEP measures the literacy achievement of American students by selecting a representative sample of students from all parts of the country, rural and urban, ethnically diverse, and public and private school students. The NAEP has recognized the shift to using technology in assessment and in students' writing specifically. The most recent NAEP in 2011 was conducted exclusively on computers (National Center for Education Statistics (NCES), 2012). The previous testing periods, 2002 and 2007 saw a significant increase in eighth and twelfth grade students' overall writing scores (Salahu-Din, Persky, & Miller, 2008).

Table 1. 1 NAEP Writing Scores 2007 and 2011 for 8th and 12th Grade Students

	2007 Paper and Pencil Assessment				2011 Computer Assessment			
	Below Basic	Basic	Proficient	Advanced	Below Basic	Basic	Proficient	Advanced
8th	12%	55%	31%	2%	20%	54%	24%	3%
12th	18%	58%	23%	1%	21%	52%	24%	3%

Data from Salahu-Din, Persky, & Miller, 2008, and NCES, 2012

The rising average score trend was broken in 2011, when the assessment was given on the computer (see Table 1. 1 NAEP Writing Scores 2007 and 2011 for 8th and 12th Grade Students). Eight graders appeared to have been affected more, with the number of students scoring at below basic increased by 8%, from 12% to 20%. The number of students performing at a basic level was roughly the same with a 1% drop, but the number of students scoring at a proficient level dropped 7%. The researchers reported that the frequency students' composed on the computer directly affected their final scores. With students who never or hardly ever used the computer scoring an average of 141, while students who always or almost always used the computer for writing scoring an average of 160. This increase in the number of students scoring at a below basic level on the computer is troubling. If assessments are going to be given on the computer, researchers and educators need to understand the effect that technology, specifically word processing, has on students' composition skills.

While fourth graders' scores increased significantly from 1998 to 2002 (no data were provided about their 2007 scores), almost three quarters of fourth graders were performing at a basic or a below basic level of writing on the paper version of the assessment (NCES, 2003). A basic level of writing skill should not be acceptable. In our increasingly global world, higher level thinking and writing is an essential skill. While this level may allow a person to function in society, it is not a level that allows for high level or strategic writing abilities. Performing at the basic level of writing skill may not be enough to meet the increasing requirements for

professional employment in the United States. NAEP researchers looked into the feasibility of fourth graders using a computer-based assessment for writing in 2012, but in the pilot study 68% of students received a score of developing skill or lower (NAEP, 2014). This indicates students are not performing at a high level of writing achievement on the computer.

The Introduction of the Common Core and the Age of Digital Assessments

The summer of 2010 introduced the Common Core State Standards (CCSS) and reshaped the literacy landscape of the American education system. The CCSS highlight the importance of all aspects of literacy: reading, writing, speaking and listening, language, as well as media and technology (Council of Chief State School Officers & National Governors Association, 2014). Forty-three states have currently adopted these standards (as of November 21, 2014). They identify anchor standards for college and career ready students for writing (pg. 18):

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

Meeting these standards requires a high level of writing skill and expertise. Students need opportunities to write, receive feedback, revise and publish pieces to become more capable writers (Calkins & Harwayne, 1987; Graves, 1983; Graves & Murray, 1980; National Commission on Writing, 2003; Ray & Cleaveland, 2004). The standards also describe the college and career ready student as able to "employ technology thoughtfully to enhance their reading, writing, speaking, listening, and language use," (pg. 7). Knowing what tools are the most useful for a given task is essential to successfully navigating this digital age. Exposure to

different technologies and practice using them for authentic purposes allows students to harness the power of various tools.

As educators and researchers know, in our high stakes testing environments, assessment is driving instruction. The Common Core highlights the importance of writing and technology and as a result writing is being assessed. Two major companies are at the forefront of designing assessments for the Common Core: SMARTER Balanced Assessment Consort (SBAC) and Partnership for Assessment of Readiness for College and Careers (PARCC). These companies have received a combined $330 million in grants to design assessments for the Common Core (U.S. Department of Education, 2010). The 2014-2015 school year will be the first year of full implementation with 21 states using the SBAC assessments and 13 states using the PARCC assessments (PARCC, 2014; SBAC, 2014). Both companies require all assessments to be given on the computer or using a tablet. Starting in third grade students' writing will be evaluated based on what they can type on the computer. The increase of computer-based assessments makes research on how young students' write and revise on the computer more crucial than ever. Traditionally, primary students have written using paper and pencil.

Cognitive Demands of Writing

Complex cognitive tasks, like writing, require large amounts of processing capacity (Ericsson & Kintsch, 1995; Kellogg, 2001, 2008). In order to write, people have to access stores of information in working- and long-term memory (Kellogg, 1996). Working-memory accesses the stores of knowledge in long-term memory when writing. Long-term memory stores knowledge about the task, topic, audience, language, and genre (Hayes, 1996). A writer must juggle the limited amount of information available in his or her working memory with the demands of the task. Working memory can only store an average of seven chunks of information

at a time (McCutchen, 1996). Low-level processes, such as handwriting, spelling, and grammar, can overload this limited capacity, leaving few resources available higher-level tasks such as planning, revision, and audience awareness (McCutchen, 1996, 2006). Planning, translating, and reviewing are basic writing processes that can burden cognitive capacity (Flower & Hayes, 1981; Flower, Hayes, Carey, Schriver, & Stratman, 1986; González & Mata, 2009). During the planning process, authors set goals, generate ideas, and organize information (McCutchen, 2006). Translating ideas into text requires transcription, which incorporates handwriting and spelling skills (McCutchen, 1996, 2006). The more fluent an author's transcription skills are, the more cognitive resources available to craft texts (Kellogg, 1999, 2001). Reviewing encompasses both evaluating and revising text (Flower & Hayes, 1981).

Revisions and Transformations

Researchers have defined revision in various ways. Successful revision occurs when the final text is closer to the demands of the task than the original (Faigley & Witte, 1981). Fitzgerald and Markham (1987) provide the most comprehensive definition of revision. They explain:

> Revision means making any changes at any point in the writing process. It is a cognitive problem-solving process in that it involves detection of mismatches between intended and instantiated texts, decisions about how to make the desired changes, and making the desired changes. Changes might or might not affect the meaning of the text, and they might be major or minor. Also, changes might be made in the writer's mind before text is written on paper, while text is written, and/or after text is written. (pg.4)

While this definition of revision captures all of the instantiations of the term, it can become cumbersome when researchers attempt to apply this definition to capture all of the revisions that

occur during the writing process. Many revisions occur in the author's mind and as a result are challenging to capture. While think-aloud protocols and post-writing interviews allow insights into the revision process, invariably verbal explanations involve bias (Allal, 2000). Allal (2000) used the term transformations to describe the changes that students made between two written drafts. These transformations are the physical manifestations of their revisions. Instead of addressing all of the various forms of revision, this study will narrow the focus of the exploration to the physical transformations students make to their texts.

Revisions can range from changing the spelling of a word to a complete reconceptualization of the original text. Surface level changes include formal changes such as correcting spelling, punctuation, or verb tense as well as meaning-preserving changes like adding, deleting, and substituting words or phrases, but not changing the overall meaning of the passage (Faigley & Witte, 1981). Text-based changes are modifications of the micro or macrostructure of the text through additions, deletions, substitutions, and rearrangements that change the overall meaning of the text (Allal, 2000).

Computers can support basic revision. First, authors have access to spelling and grammar checks as well as a thesaurus (Daiute, 1986; Figueredo & Varnhagen, 2005; Fletcher, 2001). Writers receive immediate feedback about spelling and can liven up their texts using the thesaurus feature. Simple grammatical errors can be corrected with the push of a button, relieving some of the burdens of editing. Middle school and university students can effectively use spell check to correct errors (Daiute, 1986; Figueredo & Varnhagen, 2005). Second, digital texts free the writer of space constraints when writing. Writers are provided with an unlimited amount of space in digital environments and are not constrained by the confines of a page (Cochran-Smith, 1991; Merchant, 2007). The unlimited nature of space also allows writers to

insert text in the middle of a sentence or paragraph. Texts are easily manipulated, allowing for easy additions, substitutions, and deletions. Writers can move a word, a sentence, or even a paragraph, from one section of a document to another. These technological affordances can support the revision of writers of differing levels.

Writers of differing ability levels make different types of revisions (Bereiter & Scardamalia, 1987; Faigley & Witte, 1981; Flower et al., 1986).While expert writers may view revision as a "knowledge-transforming" experience clarifying the message of the final text, student writers are notorious for their avoidance of the revision process (Bereiter & Scardamalia, 1987). Experienced writers may begin the revision process with the goal to reconceptualize the piece by strengthening its content or structure while novice writers often view revision solely as deleting and editing (Flower et al., 1986). Professional editors use their vast writing schema to quickly and efficiently identify problems with a text (Bisaillon, 2007).

Bereiter and Scardamalia (1987) describe revision in three stages: Compare, Diagnose, and Operate (CDO). First, the author Compares the written text to the intended message. Second, if the text does not match, the author Diagnoses the problem. Third, the author Operates on the text. In order to compare the written text to its intended message, the author must have a clear understanding of the goal of the writing (Bereiter & Scardamalia, 1987; Butterfield, Hacker, & Albertson, 1996). Students may overestimate the readability of a given text (Beal, 1987). If the author is not a strong reader or is unable to read the text from the reader's point of view and fails to notice the inconsistency, then it is impossible for him/her to make a revision because the mismatch is not identified. Authors may have different goals when revising a piece; they can proofread for spelling or grammatical errors or read to evaluate the overall message (Flower et al., 1986). When comparing written text to the intended message, the authors' knowledge of

writing, goals, and constraints (i.e. length requirements or time) influences their ability to identify and diagnose inconsistencies (Flower et al., 1986) When a mismatch is detected, the writer must then diagnose the problem and determine why the word or sentence does not work (Bereiter & Scardamalia, 1987). The problem could be as simple as a missing period or as complex as failing to convey the intended message. Correctly diagnosing a problem does not necessarily lead to effective revision. For example, a writer may chose to leave the text as it is because, even if he is able to diagnose the problem, he may lack the skills to make the necessary change to correct it. (Bereiter & Scardamalia, 1987). Finally, the writer has to operate on the text to solve the problem. This could be a surface change or a major revision of the text (Faigley & Witte, 1981). A writer may give an example, delete a portion of the text, rephrase, change the tone of a piece, or correct a punctuation error (Bereiter & Scardamalia, 1987; Faigley & Witte, 1981). The writer may not be cognitively aware of moving through these steps while revising, but if a writer fails to identify an inconsistency, then no revision will be made. All of these tasks required to successfully revise makes it taxing even for some advanced writers.

Revision is an essential part of the writing process. By understanding how experienced writers revise, educators and researchers can empower young children to learn about revision. Research on young children's revision strategies can serve as a guide for future revision research and broaden our understanding of the writing process.

Learning to Write in the Early Grades

Learning to write can be viewed as a natural or problematic process (Bereiter & Scardamalia, 1987). When viewed as an extension of oral language, writing appears to be a natural process. However, not all societies have evolved to create written texts; learning to write is traditionally more limited than learning to read (e.g. Scribner & Cole, 1973; Shanahan, 2006).

In societies that have written language, nascent forms of written expression are found before students enter elementary schools with drawings and markings representing children's ideas (Kress, 2000; Shanahan, 2006).Writing itself requires the orchestration of myriad skills and the highest levels of writing achievement require 20 years of maturation, instruction, and training (Kellogg, 2008).

To produce written texts, children have to encode their ideas. With novice writers the cognitive load of transcription, handwriting speed and spelling ability, interferes with text production through fourth grade (Berninger et al., 1997; Graham & Harris, 2000a; McCutchen, 2006; Negro & Chanquoy, 2005). Children must transform the words in their head into symbols on a page (Graham & Harris, 2000a). This requires children transcribe their ideas to paper by sounding out words, forming letters, and applying writing conventions (spaces between words, periods at the end of sentences, etc.) (Shanahan, 2006). In the English language, a writer uses 26 letters to represent 44 sounds, making transcription a challenging proposition for primary grade writers (Blevins, 1998). In addition, many common words are spelled irregularly, adding to transcription challenges. Children's transcription skills directly affect the quality of their written texts; those with lower transcription skills write significantly lower quality texts (Graham & Harris, 2000a). Handwriting speed and spelling ability contribute to writing fluency; as children become more fluent writers, they free up cognitive resources for higher level skills such as planning and revising (McCutchen, 2006).

The computer allows students to type and spell check texts. Using a keyboard decreases the physical burden of handwriting (Cochran-Smith, Kahn, & Paris, 1990). Freeing students from the fine motor requirements of handwriting creates more legible texts, and their hands may not become as tired. A typed text does not have to be rewritten to make changes (Beck & Fetherston,

2003; Cochran-Smith, 1991; Kendall, 2008; Merchant, 2008; Seawel, Smaldino, Steele, & Lewis, 1994), allowing time for more writing or additional time to revise. Requiring students to recopy their handwritten texts for a final draft does not enhance children's writing skills; instead, they practice letter formation and open themselves up to introducing new errors (Cochran-Smith, 1991; Cochran-Smith et al., 1990; Merchant, 2008). Most final documents in the workplace are typed. In the business world, managers do not pass out handwritten meeting notes; instead, they provide PowerPoint presentations or typed reports. Typed texts can look professional no matter the age of the writer. Elementary school students report that they prefer the published look of texts created on the computer to handwritten documents (Beck & Fetherston, 2003). The look of the final product can serve to motivate students when writing.

Word processing is not the typical way primary grade students compose texts, in a 2008 study, 42% of teachers reported they never use the computer for writing and 25% said only several times a year (Cutler & Graham, 2008). The result is young writers lack familiarity with typing texts. While computers do decrease the physical burden of handwriting and letter formation, elementary school students type significantly slower than they handwrite (Connelly et al., 2007). Few studies have compared the typing speed with handwriting speed to determine the effect on the final product, but with fifth graders the slower typing speeds leads to lower quality typed products (Connelly et al., 2007).

In today's primary grade classrooms, nearly three fourths of teachers report that they use a process approach combined with traditional skill instruction to teach writing (Cutler & Graham, 2008). A process approach to writing teaches children the steps of writing, prewriting, drafting, revising, editing, and publishing, with emphasis on the actual writing process (Tompkins, 2004). What do authors do? Where do authors get ideas? How do authors revise

texts? etc. (Graves, 1983; Ray & Cleaveland, 2004). A typical writing session in a process approach classroom begins with a mini-lesson where children are introduced to an aspect of writing. Then children have time to work on their writing pieces. At the end of the period is authors chair or sharing time where students can share their work with their peers (Ray & Cleaveland, 2004; Tompkins, 2004). Traditional skills instruction involves focusing on specific skills, such as spelling, grammar, capitalization, and punctuation (Cutler & Graham, 2008). Teachers embed these skills into their mini-lessons or teach them as separate skill activities. Teachers often support students' writing with graphic organizers, writing prompts, conferencing with students, and planning.

Revision is being taught in many primary grade classrooms. Most teachers report that their primary grade students revise their writing at least several times a month (Cutler & Graham, 2008). However, little research has examined how primary grade students revise their own texts. In classrooms children write their own texts: stories, journals, books, poems, narratives, reports, letters, reading responses, etc (Cutler & Graham, 2008). They revise their own texts or help a peer revise a text. These revisions can range from correcting spelling and punctuation to changing the intended message of a piece of writing. Young students can make informed decisions about changing their texts (Dix, 2006). Eight to ten year olds are capable of justifying their revisions. For example, children can explain how they added words to be more precise or made a substitution because it sounded better. They are cognitively aware of the power of language and how to make modifications to their writing.

Purpose of the Study

This study explores the revisions that second grade students make to narrative texts using paper and computer. While research has shown that second graders are capable of revising, little

is known about the impact of technology on these revised texts. The cognitive load of writing can affect written products, especially of young students. Capturing the cognitive load of spelling and writing fluency both on paper and the computer will reveal their effects on students' revisions. It should be noted that revision does not necessarily lead to higher quality final products. By exploring the impact of technology tools on these issues, the fields' understanding of revision and young students will be broadened.

Four classrooms of second grade students from a middle class suburban school in the Midwestern United States will participate in the study. Over the course of three sessions, students will receive training on the use of Microsoft Word: how to enter, edit, and save texts. The purpose is to provide students with an overview of the tool, but will not be sufficient to make them expert typists. The cognitive load of writing will be assessed with a writing speed and spelling assessment, both on paper and computer.

This study used a within subject crossover trial using randomized block assignment (AB | BA) for counterbalancing.. Students composed and revised two stories. All of the first drafts were written on paper. Then, the final draft was revised and edited using either the computer or paper. For the computer revision pieces, the researcher entered all of the first drafts into the computer maintaining all of the original spelling and punctuation. The classrooms were be randomly assigned to an order: first paper revision, then computer revision; or computer revision, then paper revision. The types of revisions and quality of the stories were analyzed.

This study sought to answer the following questions:

1a. Is there a significant difference between the revisions second grade students make when using handwriting or a word processor?

1b. Is there a significant difference between the change in quality from the initial to final draft of second grade students' narrative texts when revising using handwriting or word processor?

2a. What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the number of revisions second graders make to their narrative texts using handwriting? Using a word processor?

2b. What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the quality of second graders narrative texts when revising using handwriting? Using a word processor?

"Writing a text is probably the most complex task of all the language activities (i.e., speaking, understanding or reading). It requires the simultaneous implementation of multiple operations, from the mental elaboration of the message to its graphic transcription."

- Negro, 2005, pg. 105

CHAPTER II: LITERATURE REVIEW

The ability to express ideas in text opens a myriad of doors and opportunities; written communication is a powerful tool that young children are only beginning to learn to utilize (Bereiter & Scardamalia, 1987; National Commission on Writing, 2003, 2004, 2005). But learning to write is a cognitively demanding task and using the 26 letters of the alphabet to represent the 44 sounds in the English language can overwhelm even the most precocious novice writer (Blevins, 1998). Cognitive demand begins with determining how to spell a word and continues as novice writers encode letters to paper. Transcription requires spelling ability and handwriting fluency (Graham & Harris, 2000). When writing on paper, the cognitive load of transcription affects the quality of students' writing through fourth grade (McCutchen, 2006). This high cognitive load limits the resources available to plan and revise texts. Young writers are described as random drafters, either not rereading their texts or doing so in a perfunctory fashion without attempting to make revisions (Flower, Hayes, Carey, Schriver, & Stratman, 1986). Transcription technologies used also impact children's writing (Hayes, 2012). Texts may be created using pencil and paper, word processing programs, cell phones, or handwriting recognition software, among many others.

The widespread availability of information and communication technologies (ICTs) in the world makes examining the effects of technology on writing crucial. Computers and new

technologies are changing how we communicate ideas (Leu, Kinzer, Coiro, & Cammack, 2004; MacArthur, 2009; Merchant, 2008; Prensky, 2001). Digital writing physically affects how texts are created (Merchant, 2007). Instead of handwriting, digital writers sit at a desktop or laptop looking up at a screen while touch typing or hunting and pecking to enter characters. A professional product is immediately visible that can easily be shared with a wide audience through online chat, email, Facebook post, or webpage. Computers lend themselves to more collaboration and motivation while writing (Cochran-Smith, 1991; Goldberg, Russell, & Cook, 2003; Merchant, 2007, 2008), and computers provide the user with a myriad of affordances: unlimited space, editing tools like spell check, the ability to move chunks of text with ease, and the freedom from recopying (Daiute & Kruidenier, 1985; Daiute, 1983; MacArthur, 2006; MacArthur & Graham, 1996).

The affordances provided by digital writing make the computer a powerful tool for writing in our digital age. Freed from the concerns of mechanics, word processors allow writers to focus on higher-level concerns, such as idea generation and revision (MacArthur, 2006). Word processing has the potential to significantly improve the overall quality of students' writing. Two meta-analyses of research with K-12 students using paper and pencil versus computers found that the use of computers increased both the length and the overall quality of writing (Bangert-Drowns, 1993; Goldberg et al., 2003). In a meta-analysis of 4-12th grade students writing, an average weighted positive effect of .55 was found for the use of computers (Graham & Perin, 2007), in spite of the fact that students are faster at handwriting than typing through at least sixth grade (Connelly, Gee, & Walsh, 2007). The use of computers in place of handwriting also affects the revising process of young writers. Digital revising takes advantage of the affordances of technology. Surface errors can be corrected using tools like spell check, and macrostructure text-

based changes to a document can benefit from the unlimited space for writing and the ease of being able to cut and paste large chunks of text.

While researchers have made strides in the literature base regarding writing with older students, little is known about how technology is leveraged to support our novice writers. Writing at its most basic level is the encoding of words on paper, but effective communication requires the orchestration of a wide array of skills. Cognitive theories provide insights into the challenges of learning to write and revise successful texts. This research seeks to determine the effect of the cognitive load of transcription, measured with writing speed and spelling ability, on the revisions second grade students make to their narrative texts using two transcription technologies: handwriting and typing. This study is informed by research from the following areas: (a) writing from a cognitive perspective, (b) cognitive load theory, (c) kindergarten to fourth grade students' writing, (d) transcription, (e) transcribing technologies, (f) revision, and (g) quality of writing.

Writing from a Cognitive Perspective

Writing is a complex cognitive task. Authors juggle countless thinking processes while composing: planning, idea generation, transcription, revision, and many others (Flower & Hayes, 1981; Hayes, 1996; Hayes, 2012). The strain of balancing these varied tasks may interfere with text production. Cognitive theories have the potential to provide insights into the composition process. From a cognitive perspective, learning takes place within individuals (Ashman & Conway, 1997). Cognitive theories seek to understand how knowledge is constructed and constrained by individuals' cognitive architecture (Paas, van Gog, & Sweller, 2010). Information is stored in long-term memory (LTM) and is accessed through working-memory (WM) (Ericsson & Kintsch, 1995; Kellogg, 1996). This perspective is ideal for guiding this study because the

cognitive capacity of second grade students impacts their ability to write and revise texts. The cognitive load of transcription affects writing quality and speed through fourth grade (McCutchen, 2006) leaving few resources available for revision.

Plan. Write. Revise. These three steps paint a simplistic picture of the writing process (Flower & Hayes, 1981; Graves, 1983). In reality, though, writing is a messy proposition. Writers can jump in or out of each of the phases at any point in the process (Hayes, 2012). During the planning phase, writers set goals for their writing, generate ideas, and organize their thoughts (Flower & Hayes, 1981; McCutchen, 2006). Writers in this phase must solve problems and make decisions about what to include in the text, as well as decide the best way to organize the information (Hayes, 1996). An effective author must infer what a reader already knows and use that understanding to plan their writing. To generate text an author must select content, retrieve words, apply syntax rules, spell words, and form letters (McCutchen, 2006). Revision requires that the author compare generated text to their writing goals, which requires a critical reading of the text (Hayes, 1996). At any time all of these processes can be overloaded by the limited resources available in working-memory, preventing writers from achieving their full potential.

Working-memory (WM) limits the amount of mental power available for writing. It acts as the "workbench" where information is stored and accessed during cognitive tasks (Woolfolk, 2013). WM holds a limited amount of data for a limited time period, approximately 5 to 20 seconds (McCutchen, 2006). The capacity of young children's WM can be easily overloaded, limiting their ability to write (Kellogg, 2001; McCutchen, 1996, 2000). As lower level skills, such as letter formation, become more fluent and require the use of less working memory, cognitive resources are freed, which allows for more complex thinking and learning to occur.

Current models include four elements of WM: central executive, phonological loop, visuospatial sketchpad, and episodic buffer (Baddeley, 2002). These elements of WM play an essential role in the writing process, affecting all aspects of writing and the load of various writing skills. The central executive oversees attention, plans, determines what information to retrieve, and allocates WM resources. The phonological loop is responsible for holding and rehearsing speech and sound units in WM. It is capable of holding information for 1.5 to 2 seconds. The phonological loop can hold the next word an author wants to write. The visuospatial sketchpad is where mental images, like letter forms, are stored within WM. Finally, the episodic buffer serves as the "workbench of working-memory" (Woolfolk, 2013). Here information is integrated from the phonological loop, visuospatial sketchpad, and LTM. The episodic buffer uses multimodal code to capture information and organize it into episodes or scenes. Using confirmatory factor analysis, Vanderberg and Swanson (2007) found that the central executive component of WM predicted planning, translating, revision, higher order microstructure skills, and vocabulary with tenth grade students. WM as a whole is a key factor in determining a student's ability to produce high quality texts.

A second type of memory affecting the writing process on a cognitive level, long-term memory (LTM) permanently stores information in what appears to be an unlimited amount of space (Woolfolk, 2013). Spelling, letter formation, genre, task schemas, topic knowledge, audience knowledge, linguistic knowledge, and genre knowledge are all stored in LTM (Ericsson & Kintsch, 1995; Hayes, 1996; McCutchen, 2000). The greater stores of information in LTM account for the increased capacity of experts (Ericsson & Kintsch, 1995). Experts in any given field have highly organized retrieval structures that allow them to access information effectively (Ericsson & Kintsch, 1995; Kalyuga, Renkl, & Paas, 2010; Sweller, 1988). By mastering the

basic skills required to transcribe text, additional capacity in LTM allows experts to spend more time focusing on higher level tasks like goal setting, idea generation, and revision.

This study focuses on three aspects of writing: transcription, transcribing technology, and revision. Hayes (2012) explains that writing processes are overseen by an evaluator process that examines the proposed ideas, translates them into coherent thoughts, and finally transcribes those words to paper or the screen. The effect of transcription is especially important for novice writers and constrains writing quality through fourth grade (McCutchen, 2006). Transcription involves knowledge of spelling and writing fluency (Berninger & Swanson, 1994; Graham & Harris, 2000; Hayes & Berninger, 2010; McCutchen, 1996, 2000, 2006). Transcribing technology can significantly affect the quality of the final product (Hayes, 2012). People typically learn to write using paper and pencil; the familiarity of this mode can decrease the cognitive load for younger writers (Connelly et al., 2007). On the computer individuals have access to spell check, can easily move text, and have unlimited space. The different affordances of the mediums can affect the length and quality of writing (Goldberg et al., 2003). Revision is a specialized writing activity that requires the author to detect problems, plan a solution, and transcribe new text (Hayes, 2012). Effective revision utilizes a large number of cognitive resources, tying up WM (Butterfield, Hacker, & Albertson, 1996).

Cognitive Load Theory

Cognitive load theory (CLT) provides a foundation for studying complex cognitive tasks, where learners can be overwhelmed, limiting their capacity to perform (Sweller, Ayres, & Kalyuga, 2011). While researchers in other areas, like mathematics, have extensively used cognitive load theory, its application to writing research has been primarily theoretical (e.g. Hayes & Berninger, 2010).

The essential tenets of CLT make it ideally suited to the study of revision by second grade students. The cognitive load of writing may interfere with young students' abilities to revise texts. The first application of the tenets of CLT in this situation is the recognition of the importance of the human cognitive architecture with respect to WM and LTM (Sweller et al., 2011). When physically writing, the cognitive load of transcription can easily overwhelm the WM of novice writers, limiting resources for higher-level processes. An additional tenet is the importance of the intrinsic, extraneous, and germane loads. Writing has many intrinsic elements that make it a challenging task for novice writers. Letter formation, spelling, and idea generation tie up WM resources limiting capacity (McCutchen, 2000). Another tenet of CLT highlights that learning must be tied to domain-specific knowledge, not general theories of learning. Students need to be explicitly taught how to revise when writing. The final tenet of CLT requires researchers to test hypothesis to prove the effects of cognitive load on learning. By measuring the cognitive load of transcription based on writing speed and spelling ability using two transcribing technologies—pencils and computers—this study seeks to determine the impact on the revision of second grade students. However, cognitive load cannot be directly measured.

To determine an actual value for cognitive load, researchers must measure indicators of the WM and LTM available during a given task (Ericsson & Kintsch, 1995). Other indicators can be used as a proxy to measure the cognitive load of a given task, as well. By determining appropriate indicators, researchers can apply CLT to writing research and uncover the effects of working memory. The students' writing speed and spelling ability in both mediums serve as a proxy to measure the cognitive load of transcription.

Kindergarten to Fourth Grade Students' Writing

As students gain experience writing, major changes occur between kindergarten and fourth grade (Bereiter & Scardamalia, 1987; Gentry, 1982; McCutchen, 2006). Children begin writing by using seemingly random letters to represent words, and by the end of fourth grade, they should be able to produce fluently written stories and expository texts using appropriate spelling (Gentry, 1982; McCutchen, 2006). Novice writers in particular are limited by the high cognitive demands of writing. Writing requires that individuals remember how to form letters, understand the letter sounds, and know what they want to write, as well as understand their production goals. To deal with the cognitive load of writing, young children often use a knowledge-telling strategy (Bereiter & Scardamalia, 1987).

Knowledge-telling

Young students appear to jump into writing with relative ease and little planning (McCutchen, 2000). Novice writers in particular may employ a knowledge-telling strategy for writing (Bereiter & Scardamalia, 1987; Kellogg, 2008). With knowledge-telling, students' planning tends to be limited to idea retrieval (Kellogg, 2008). Students write whatever they are thinking with little attention to the task or audience (Bereiter & Scardamalia, 1987). Their ideas are cued by the previous sentence, topic, or genre. This strategy is useful because it allows beginning writers to get their ideas down on paper (McCutchen, 1996). Translating ideas into text is a cognitively demanding task because of the strain of letter formation and spelling while generating content (Berninger & Swanson, 1994; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; McCutchen, 1996). The cognitive burden of text production impairs young writers' abilities to engage in higher level writing processes, such as planning and revision.

McCutchen (1988) introduces the term "functional automaticity" to describe children's writing. In reading and math, automaticity is a useful skill. Children memorize math facts and

recognize sight words automatically. This decreases the cognitive load of these tasks; however, being highly routinized makes these cognitive procedures difficult to penetrate or break apart. This is not effective when writing. For writing, children need to be able to jump in and out of various stages (e.g. planning, revision, idea generation) at any point in time. If, for example, word choice is routinized, then writers will not interact with the choice to strengthen or modify their texts. Functional automaticity makes it possible for young writers to use a knowledge-telling strategy, but leaves few resources for planning or revision. Young writers are not without goals, but their goals may be limited to trying to spell a word correctly or stay on topic while writing. To move students beyond the knowledge-telling stage of writing, they must be challenged. These early writing years serve to provide students with a sense of what writing is and develop fluency. Fluency, not automaticity, allows students to interact with their texts at a deeper level and make meaningful choices about their writing.

Children develop writing skills at different rates based on their cognitive abilities, what they have been taught, and opportunities to practice. While students may continue to use a knowledge-telling strategy beyond elementary school, some students in fourth grade are capable of using a higher-level knowledge-transforming strategy (Bereiter & Scardamalia, 1987; McCutchen, 1988). Kellogg (2008) argues that it takes an average of 10 years to move from one stage to the next, from knowledge-telling to knowledge-transforming, to a professional writers' knowledge-crafting stage. The knowledge-telling strategy that young writers' use eases the cognitive load of writing, allowing them to begin to develop writing fluency.

Transcription

Text Production and the Cognitive Load of Transcription

Transcription is comprised of spelling ability and handwriting fluency (Berninger & Swanson, 1994; Graham & Harris, 2000; Hayes & Berninger, 2010; McCutchen, 1996, 2000, 2006). Rapid handwriting speeds allow writers to get ideas down before they are forgotten. This is impacted by spelling ability. Being able to quickly spell, or represent enough phonemes to be reread, is essential to text production. In elementary school students, WM is overloaded with the demands of transcribing text. Hayes and Berninger (2010) provide a theoretical model of the cognitive loads of writing with first to sixth graders (see Figure 2.1). Transcription takes up the bulk of the cognitive resources during the writing process, leaving little WM available for setting goals, idea generating, translating, or revising texts. When children cannot quickly and automatically encode and produce letters, translating ideas into written text is impaired (Berninger et al., 1992). As children struggle to get their ideas on paper, they forget their next idea before it is encoded. Writers transcribe their ideas in language bursts—groups of words that are written at one time (Hayes & Chenoweth, 2007). Language bursts are limited in elementary students because of the cognitive load of transcription. They lack the ability to hold more words in their working memory to write because they must attend to lower level tasks such as letter formation and spelling. Prelinguistic ideas may be abandoned when language is difficult to encode (McCutchen, 2006). The high cost of transcription is one of the primary reasons that novice writers tend to use a knowledge-telling strategy while writing (Bereiter & Scardamalia, 1987; McCutchen, 1988, 1996, 2000, 2006).

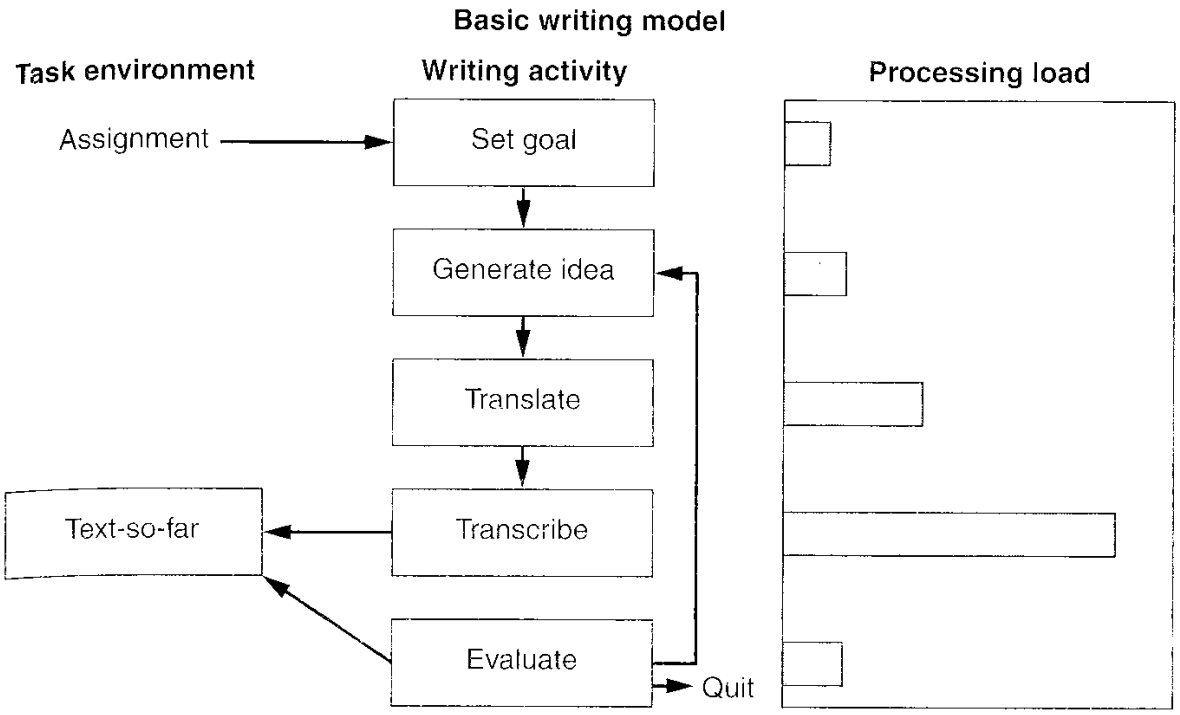

Figure 2.1. Writing cognitive loads for 1st to 6th graders from Hayes and Berninger (2010). This figure provides visual representation of the processing load for various writing activities.

The cognitive load of transcription decreases with age and schooling (Graham & Harris, 2000). However, with beginning writers, the physical effort, cognitive attention, and fine motor control required for transcription interferes with text production (Negro & Chanquoy, 2005). Students with lower transcription skills write lower quality texts (Graham & Harris, 2000). Through fourth grade, students dictating and writing texts demonstrate that they are capable of orally telling more elaborate stories than when handwriting (Bourdin & Fayol, 1994; McCutchen, 2006). From kindergarten through third grade, 66% of the variance in writing fluency is accounted for by handwriting and spelling, with handwriting contributing to more of the variance (Graham et al., 1997). The number of sentences written, the speed of letter formation, and spelling ability account for significant amounts of variance in writing quality for first and second grade students (McCutchen, 2000). In a national survey, primary grade teachers reported that during a typical week they spend a significant amount of instructional time on

transcription skills—74 minutes on spelling and 46 minutes on handwriting (Cutler & Graham, 2008).The amount of instructional time dedicated to transcription and its impact on text quality makes it an important indicator in writing research with young students.

A basic level of handwriting skill is required for children to be able to write a text that can be read and accessed by a wider audience (Dunsmuir & Blatchford, 2004). Handwriting fluency is affected by the ability to remember the shape of letters and form them without using supports in primary grade students (Graham et al., 1997). Handwriting fluency is measured using a variety of means. Students are typically given a set period of time, one or two minutes, to complete a handwriting task. Then, they are asked to write the letters of the alphabet or copy a sentence that includes all of the letters of the alphabet, such as "The quick brown fox jumps over a lazy dog," as quickly and accurately as possible (Berninger et al., 1992; Christensen, 2004; Connelly et al., 2007; Jones & Christensen, 1999). The samples are scored by giving one point for each letter formed correctly in the correct order. First and second grade students make more errors in letter formation when asked to write letters in alphabetical order than when asked to copy a sentence (Graham, Struck, Santoro, & Berninger, 2006). An alternative method of measuring writing fluency is counting the number of letters or words written in a limited amount of time. For example, students are given a writing task with a set number of minutes to write (no more than 15), and then the number of words per minute is calculated (Graham et al., 1997; Graham et al., 2006; Olinghous, 2008). These assessments serve as proxies to measure the cognitive load of transcription, specifically handwriting fluency while writing.

Spelling ability also contributes to the high cognitive load of transcription for primary grade students. The English language has many alternatives for phonemes; deciding which combination of letters makes a particular sound in a word is challenging for elementary students

(Berninger et al., 2002). Berninger et al. (2002) give the example of alternatives, or alternations, for spellings of the long a sound: *a*pron, t*ea*m, *ai*m, g*a*m*e*, th*ey*, *eigh*t. While most phonemes do not have that many alternations, identifying the correct spelling of words in English is a challenge especially for developing writers.

Spelling correlates with grammar scores and quality for fourth and fifth graders (Glaser & Brunstein, 2007; Walter & Connelly, 2010). Research has shown that instruction in spelling can improve writing fluency (McCutchen, 2006). As students gain knowledge of spelling and phonemes, the cognitive load is decreased to a more manageable level, which allows students to attend to more complex writing tasks, such as revision (McCutchen, 1996). Spelling ability is measured using varied means. Achievement tests include measures of spelling ability; assessments like the Wide Range Achievement Test (WRAT) (Wilkinson & Robertson, 2006). provide standardized scores for children and adults by age (e.g. Graham et al., 1997; Vanderberg & Swanson, 2007). Other research has examined an individual's spelling within a composition as a measure of spelling ability (Olinghous, 2008; Olinghous & Leaird, 2009). These assessments also serve as proxies to indirectly measure the cognitive load of spelling on transcription abilities.

In 1992, Berninger et al. conducted a study with 300 first, second, and third grade students to determine the lower-level developmental skills in beginning writing. They found that lower-level developmental measures, such as neuromotor function (finger mobility), were the best predictors of handwriting, spelling, and composition quality with primary grade students. Higher-level verbal reasoning was not a reliable predictor of writing quality. In a larger study that included the 300 primary grade students, as well as an additional 300 fourth to sixth graders and 300 seventh to ninth graders, Berninger and Swanson (1994) proposed a modified model of

Hayes and Flower's model of skilled writing. Fluency was correlated with text generation and reflected by handwriting speed and spelling ability across grade-levels. They found that idea generation occurs before transcription skills are mastered. Orthographic and orthographic motor integration skills contribute variance to handwriting from primary grades through junior high. The production factors and the mechanics of handwriting may contribute to the fluency and quality of texts beyond the primary grades. When primary grade students reread their texts, some showed a disassociation between the text read and the text that was actually written. This provided evidence that while memory was available for creating the ideas, they were unable to transcribe them. One negative of this study is the short writing time provided for the students. They were only given five minutes to write about the topic, allowing only limited insights into their writing abilities. In classroom settings, children typically have more time available to write a text. The quality of a five-minute text might be different from a 15- or 20-minute text. Overall, however, the large sample, extensive data collection, and varied ages of the participants make their findings reliable.

Olinghous (2008) examined student and instruction-level predictors for narrative writing with 120 third grade students. Students were given five minutes to plan and 15 minutes to write a narrative about a line drawing. She also collected data from standardized assessments for word reading, IQ, and grammatical understanding. Students completed a handwriting task where they copied a sentence as many times as possible in one minute. Writing fluency was calculated based on the number of words they wrote in their composition. Spelling was measured based on the words spelled correctly in the text. Olinghous required the words be correct in context, which is a higher standard than found in some research (e.g. Vanderberg & Swanson, 2007). Narrative quality was measured using a rubric with possible scores ranging from one to seven with anchor

texts as examples. Olinghous determined significant unique predictors for compositional fluency were gender, handwriting fluency, and advanced planning. Third grade students, who wrote faster based on the handwriting task, were able to write more during the narrative writing activity, indicating that the increased handwriting fluency freed up additional resources for idea generation. Quality of narratives was predicted by gender, fluency, IQ, word reading, and grammatical understanding.

In another study, Olinghous and Leaird (2009) examined the writing of second and fourth grade students. They found significant correlations between compositional spelling and quality for the second grade students. Compositional length, which is an indication of writing fluency, and spelling explained 31% of the variance in quality in second grade and 53% of variance in fourth grade; however, most of this variance was due to commonalities. These studies provide further evidence that handwriting fluency and spelling ability are important cognitive factors in primary grade students' writing with regards to the quality of their texts.

Each of these studies demonstrates the importance of assessing the cognitive load imposed by handwriting speed and spelling ability. Novice writers can be overwhelmed by transcription demands. By measuring and controlling differences in these areas, researchers can better understand the effect on higher level writing skills, such as revision. Word processing introduces new challenges and supports for students by allowing digital transcription.

Digital Transcription

Digital writing provides the writer with additional supports for transcription not available when handwriting, such as access to spell check and the ability to revise without having to rewrite. Understanding how digital transcription affects how students write and revise texts is imperative because computers are often used to type texts in both educational and professional

environments. The cognitive load of transcription is directly impacted by typing on a computer. Word processors impact an individual's writing speed and spelling. Recent research has examined the impact of digital writing on texts (e.g. Christensen, 2004; Connelly et al., 2007). Typing fluency is not equivalent to handwriting fluency and must be examined separately. Christensen (2004) found that with eighth and ninth grade students there is a relationship between writing fluency and quality in both handwriting and typing. By eighth and ninth grades, students were able to write longer texts on the computer than on paper, indicating they were more fluent digital writers. Typing speed is often faster than handwriting speed in older students and adults while for young children the opposite is true. In elementary school, children handwrite significantly faster than they are able to type, (Connelly et al., 2007; Crook & Bennett, 2007) indicating the cognitive load of transcription is higher on the computer than on paper.

From first to sixth grade, children's handwriting and typing speeds continue to significantly increase each year except between second and third grades (the authors of the study believe this could be a result of a type I error) (Connelly et al., 2007). Handwriting also continues to be significantly faster than typing across grade-levels. In a two-minute sentence-copying task, second graders handwrote an average of 66.8 letters and typed 24.1. In a second study with fifth and sixth graders, Connelly et al. (2007) found that typed texts, rather than handwritten, were significantly lower quality based on the Weschler Objective Language Dimensions (WOLD) written expression subscale. Based on age equivalent scores, students' typed texts scored 18 to 24 months behind their handwritten texts. In the sample, four students were faster at typing than handwriting, all still scored higher on their handwritten compositions. Four students scored higher on their typed texts than handwritten text, all were faster at handwriting than typing, and three were exceptionally fast handwriters. Walter and Connelly

(2010) found low typing speeds constrained the quality of fourth and fifth grade students' writing. These differences in the writing fluency between typing and handwriting indicate a significant difference in the cognitive load required for the mediums. This dissimilarity between the typing and handwriting speeds can directly affect the quality of students' writing. Examining writing speed is imperative when studying young children's digital and handwritten revisions. Spell check provides feedback to students and can help them self-monitor their writing (Daiute, 1983; Bangert-Drowns, 1993; MacArthur, 2006). Ninth grade English Language Learners were able to use spell check to generate more unique words when writing on a computer than when handwriting (Gupta, 1998). The spell check provided them with the confidence to attempt to spell more challenging vocabulary. However, some of the words they were able to spell correctly on paper, they misspelled on the computer.

Figueredo and Varnhagen (2005) conducted a study with college students using spell check or a dictionary to revise researcher created texts. The researchers modified the spell check options providing one correct option and two incorrect spellings, for example, retrospect, retrispect, retrespect. This study found that spelling ability was significantly correlated with the correction rate for the dictionary condition and not the spell check condition. Students made significantly more corrections in the spell check condition. However, all of these findings are questionable because of the design of the task. In a real world setting, spell check provides the user with spellings of actual words, not non-word distracters.

MacArthur and Graham (1996) conducted an extensive review of ten spell check programs for students using misspellings from sixth and seventh grade students with learning disabilities. The quality and reliability of spell checkers varied greatly, and none of them were able to detect misspellings that were actually correct spellings of other words, which was the

case in 37% of the students' misspellings. MacArthur and Graham (1996) conducted a study with sixth and seventh grade learning-disabled students. Students typed a text over two days. The next day they were given a printed copy of their text to correct spelling, capitalization, and punctuation by hand. Four to eight days later, they were allowed to use spell check on their uncorrected text. The researchers found that on the printed copy of their texts, students found 28% of their errors and corrected 9%, while on the computer they were able to find 63% of the errors and corrected 37%. These findings indicate that spell check can support students' writing processes.

In research with elementary school students, spell check has proven beneficial. When correcting errors on a researcher created text, fourth and fifth grade students using the spell check where able to identify all of the spelling errors and correct 78% (Jinkerson & Baggett, 1993). When using a dictionary they were only able to identify 56% of errors and correct 80% of the identified errors. Although students were able to identify and correct more errors using the spell check, they had lower comprehension of the text, indicating they were focused on correcting spelling. In other research with fourth and fifth graders, Walter and Connelly (2010) found students' texts had fewer spelling, grammar, and usage errors when using spell check than when handwriting or using the computer without the spell check. Taken together, each of these studies paints a clear picture of the ability of spell check to support the writing processes of elementary school students.

Fletcher (2001) conducted a case study with eight second grade students who handwrote and revised three book reviews on a computer which resulted in his claim that second graders could not be expected to use spell check like older students. His study findings are questionable; this study was limited because of the small number of texts analyzed. In the study, the teacher

typed a text previously written by the students, then the students reread the text to correct any errors, and finally they used the editing tools to make changes. The researcher found that the students corrected more errors when using the word processor alone than when using the editing software. These three texts were used to provide evidence of the small number revisions made using the word processor editing tools. Besides the small sample size used in the study, no examination was made of how many suggestions the editing tools provided. It is unclear if the software did not have any additional changes or if the children chose to ignore the suggestions. The lack of systematic analysis makes these findings altogether questionable.

While typing texts may slow down transcription rates of younger students, the spell check may lessen the cognitive load of spelling. Research has shown students have fewer spelling, grammar, and usage errors when writing on the computer than when handwriting. Further research would provide a greater understanding of the impact of spell check on students' writing. The benefits of spell check have to be weighed against the slower typing speeds for students' sixth grade and younger.

Transcribing Technology

Digital Writing with Young Students

Although there is some evidence in the literature base that young writers can use transcribing technologies, such as computers, to create texts, this line of research is still relatively nascent, particularly in applications with K-4 students (e.g. Lankshear & Knobel, 2003). This is not only a hole in the literature, but an artifact of the lack of computer use in general with lower elementary students. While many classrooms have computers available, schools may lack the resources for all of their students to have the opportunity to regularly compose texts digitally. Forty two percent of primary grade teachers report that they never use

computers for students' writing and only 25% of teachers use computers for writing several times a year (Cutler & Graham, 2008). Research in this area may provide insights into what happens when children have the opportunity to write digital texts.

When compared with paper and pencil writing, digital writing may positively influence the quality of students writing (Jones, 1994; Jones & Pellegrini, 1996), but the results are not guaranteed (Englert, Manalo, & Zhao, 2004; Shaw, Nauman, & Burson, 1994; Van Leeuwen & Gabriel, 2007). Other studies have examined the length of students' paper and pencil and word-processed writing. These studies also have had positive (Barrera, Rule, & Diemart, 2001; Englert et al., 2004; Seawel, Smaldino, Steele, & Lewis, 1994), neutral (Englert et al., 2004), and negative results (Shaw et al., 1994; Van Leeuwen & Gabriel, 2007). In a meta-analysis of writing research with first to sixth graders, Graham, McKeown, Kiuhara, and Harris (2012) found that elementary students benefited from writing on a word processor with an average weighted effect size of .47. The potential benefits of word processing need to be further explored through additional research.

Research has shown digital writing can have a positive effect on young writers. Jones (1994) conducted a counterbalance pretest-posttest study with second graders. In the study, students were randomly assigned to one of two groups. For four weeks, one group used the computer to compose texts, and the other group used paper and pencil. The following four weeks the children switched conditions. Each piece was scored by three reviewers and given an average holistic score. The score was based on theme, setting, characterization, descriptions, and emotions. After the first group wrote digital texts for four weeks, they scored significantly higher on the holistic score than the group that only wrote paper and pencil texts. One feature of this study is that the students were scored on their performance on a paper and pencil text, not an

actual comparison of their digital and handwritten texts, providing evidence that the effects of digital writing on students can extend to their handwritten products. Perhaps oddly, Jones found no significant difference in the number of words between the two groups.

In an 11-week study with first grade students, Jones and Pellegrini (1996) also found that students' digital texts were more lexically dense and cohesive than their paper and pencil texts but there was no significant difference between the two in terms of narrative structure. The strengths of these studies are the multiple measures of quality used to assess students 'writing and extended length of intervention providing a fuller picture of their capabilities.

Evidence does exist contradicting the results of these studies. In a yearlong study of a class of first graders, Van Leeuwen and Gabriel (2007) found students' digital and handwritten texts were of similar quality. They explained that they evaluated the pieces by focusing on the students' ideas and order, as well as conventions of language, but they did not provide a systematic explanation of their analysis. They found that paper and pencil texts were longer than the digital texts. The researchers noted that students' typing slowed after 10 to 15 minutes, which could have caused the shorter digital text length. It is unclear if the students were tired of typing or other factors caused this change. Shaw et al. (1994) claimed that the handwritten texts created by third grade students were better organized and expressed the children's ideas more effectively. While the authors state that the paper and pencil texts were of better quality than the typed texts, their data are questionable. This three-year study examined 72 third grade students' computer created texts and handwritten texts. They did not provide any information about how the children's texts were analyzed only what they found. Similarly, Shaw et al. (1994) described the computer texts as "stilted," but did not explain what they meant by the term. Without supporting data the reader cannot determine the validity of their findings.

Other research has found significant difference in the quality of handwritten and typed texts for young writers, as well. Englert et al. (2004) conducted a study with 18 first and second graders in three different conditions: paper and pencil, digital writing, and scaffolded digital writing. In the scaffolded writing condition, students were provided with prompts to guide their writing as well as access to spell check. The researchers replicated the study two months later and found that when provided scaffolded writing support on the computer, students performed significantly higher on holistic scores, organization, and newsworthiness scores than when the students wrote in the unsupported or handwritten condition. In other words, the support provided by the software enhanced quality of the students' writing, but typing alone did not. From these results it appears that computers can scaffold students' during the composing process and enhance the quality of their writing. While this study has a small sample size, the researchers used three different rubrics (conventions rubric, primary trait rubric, and a final rubric with word count, number of sentences, and idea units) to evaluate the quality of students writing allowing them to more fully capture differences between the conditions. This study demonstrates the impact that digital writing with computer scaffolding can also have a positive impact on the quality of writing.

Each of these studies varied on the length of intervention, the type of instruction, and the methods of measuring quality. While they do not provide overwhelming evidence that word processing improves quality, they effectively demonstrate that in some settings there are positive effects. Further research in this area is needed to determine how digital writing should be introduced and used with young students. The mixed findings in these studies are consistent with the contrastive findings of previous reviews of literature with older students (Bangert-Drowns, 1993; Cochran-Smith, 1991; Goldberg et al., 2003).

Revision

Defining Revision and Transformation

Revision is an advanced writing process that has a high cognitive cost. It has been defined in numerous ways, from low-level text editing to high-level reconceptualization of texts (Butterfield et al., 1996). Fitzgerald and Markham (1987) provide a detailed definition of revision:

> "Revision means making any changes at any point in the writing process. It is a cognitive problem-solving process in that it involves detection of mismatches between intended and instantiated texts, decisions about how to make the desired changes, and making the desired changes. Changes might or might not affect the meaning of the text, and they might be major or minor. Also, changes might be made in the writer's mind before text is written on paper, while text is written, and/or after text is written." (pg.4)

This definition captures the full range of skills required for successful revision: goal setting, grammatical and spelling knowledge, reading comprehension, critical analysis of text, problem solving, and others. Revision can be as simple as fixing a spelling error or as major as rewriting an entire text. Revisions can be readily evident or can leave no artifacts because the writer decided to change the text before the pen hit paper (Fitzgerald, 1987; Flower & Hayes, 1981).

To study revision, researchers must first capture a cognitive process that leaves somewhat limited artifacts. Think-aloud protocols that involve subjects saying verbally what they are thinking while writing and revising can be used with older students and adults (e.g. Joram, Woodruff, Bryson, & Lindsay, 1992). These verbal protocols tie up cognitive resources and can interfere with their revision processes (Berninger & Swanson, 1994; McCutchen, 1996). Interviews post-revision can provide insights into revision processes, but subjects may forget

their reasoning before the interview or not have a conscious reason for their decision-making (e.g. Bisaillon, 2007; Dix, 2006; Fitzgerald & Markham, 1987).

Capturing the full spectrum of revision, from ideas that are discarded before the pen hits paper to changing the order of a paragraph to make it flow better, is challenging, and methods to capture these revisions can tax the limited cognitive capacity of writers. Researchers may instead focus on the artifacts of revision. By focusing on the transformations—the physical changes that occur to the text from one draft to the next—researchers can gain insights into the revision processes without affecting the phenomena they are studying. Allal, Lopez, Lehraus, and Forget (2005) further explain the term "transformations:"

> "Transformations are an indicator that revision has occurred, but the absence of transformations does not necessarily imply an absence of revision. When an author reads a passage, finds it satisfactory and leaves it unchanged, the revision process is nonetheless present. Learning to revise entails learning when and how to make transformations, as well as learning when not to make transformations." (Allal et al., 2005, p. 73)

Examining the transformations of writers provides a window into the revision process. While some revisions are lost as they do not make their way to the paper, the integrity of these transformations remains intact because cognitive resources are not being drained by think aloud protocols or other means.

What Happens When Revising a Text

Revision is a cognitively taxing task. The person revising must read and comprehend the written text, compare it to the goals of the writing, and evaluate to determine if it is effective. Once the reader has identified an error, he or she must find a way to solve the problem. WM

struggles to balance the goals of the writing and access knowledge stores of syntax and spelling from LTM, at the same time it decodes and evaluates written text. When an error is detected, LTM is accessed to find possible solutions to the problem. The fluency of the lower-level cognitive skills, such as spelling and grammar knowledge, can free up resources for revision.

Butterfield et al. (1996) created a model of revision that explains the role of WM and LTM in the process. WM is responsible for: (1) representing the rhetorical problem, plan, and standards of evaluation for the text; (2) reading to represent and comprehending the actual text; (3) detecting and diagnosing problems in the represented text; (4) selecting, modifying, or creating strategies for revising the represented text; (5) translating revisions from represented text to actual text. The five different areas that WM is balancing can tax even the resources of a mature writer.

LTM is accessed throughout the revision process (Butterfield et al., 1996). WM accesses LTM for metacognitive and cognitive knowledge about topic, language and writing, and standards of evaluation, as well as understanding strategies for thinking, reading, and writing. LTM is accessed to apply grammar and semantic knowledge, make instantiations and factual inferences, use schemas and world knowledge, apply genre conventions, identify gist, infer writers' intentions and point of view, and consider audience needs. All of this takes place while the writer is trying to decode the written text, which with primary grade students can be a challenge in itself. This process leads to the possible discovery and identification of problems. These tasks can quickly overload the cognitive capacity of young writers, limiting their ability to make effective revisions. If the cognitive load of reading the text is too great, then the problems cannot be detected.

Revision also can break down at any point in the writing process. Failing to set clear goals for writing or failing to identify grammatical errors during a final proof reading of the text may lead to the breakdown of revision (Fitzgerald, 1987). Another revision breakdown can occur if an author fails to take into account the needs of the reader (Butterfield et al., 1996). Authors familiarity with a subject may lead to an overestimation of reader knowledge, which causes them to fail to provide the reader with enough information to comprehend their text (Hayes & Bajzek, 2008; Mcutchen, Francis, & Kerr, 1997). Young writers tend to focus on text generation, not on the needs of the reader (McCutchen, 2006). Individuals assume that the reader has the same information they do. When revising their own texts, students know what they intended to write and may not see problems within the text. Without problem identification, the reviser will not seek solutions to those problems (McCutchen, 1996). After a problem is identified, the writer must select a strategy: rewrite, revise, or ignore (Flower et al., 1986). At times children can identify a problem but are unable to determine how to solve it (Beal, 1987, 1990, 1996; Butterfield et al., 1996). Another challenge is determining alternate language (McCutchen, 2006). Even when writers attempt repair problems, they may not actually fix the issue and may introduce new errors in the process (Cochran-Smith, 1991).

When young writers revise, because of their limited WM resources, they typically use a sentence-by-sentence approach that fails to allow them to make more global revisions (McCutchen, 2006). Adults and older students have more WM available allowing them to concentrate on higher-level processes like revision and planning because they do not have to attend to lower-level transcription processes (McCutchen, 1996, 2006). Elementary students master text generation skills before gaining control of revision processes (Berninger & Swanson, 1994). While elementary school students are less skilled revisers, it is possible to prompt revision

even during the knowledge-telling stage (Brunstein & Glaser, 2011; Chanquoy, 2001; Dix, 2006; Fletcher, 2001; Nuvoli, 2000).

Analyzing Revision

Once researchers have identified what aspect of revision they are going to study and how they will capture it, they need a systematic method to analyze the revisions. Faigley and Witte (1981) developed the seminal taxonomy of revision changes that continues to guide research today. Many studies base their revision analysis on their taxonomy (e.g. Daiute, 1986; Dix, 2006; Fitzgerald & Markham, 1987; Pifarré & Fisher, 2011; Yagelski, 1995). Faigley and Witte (1981) explain, "Successful revision results not from the number of changes a writer makes but from the degree to which revision changes bring a text closer to fitting the demands of the situation," (pg. 411). The basis of the taxonomy is the effect the change has on the overall meaning of the text (see Figure 2.2). Revisions are categorized as surface or text-based. Surface changes do not change the overall meaning, while text-based changes do.

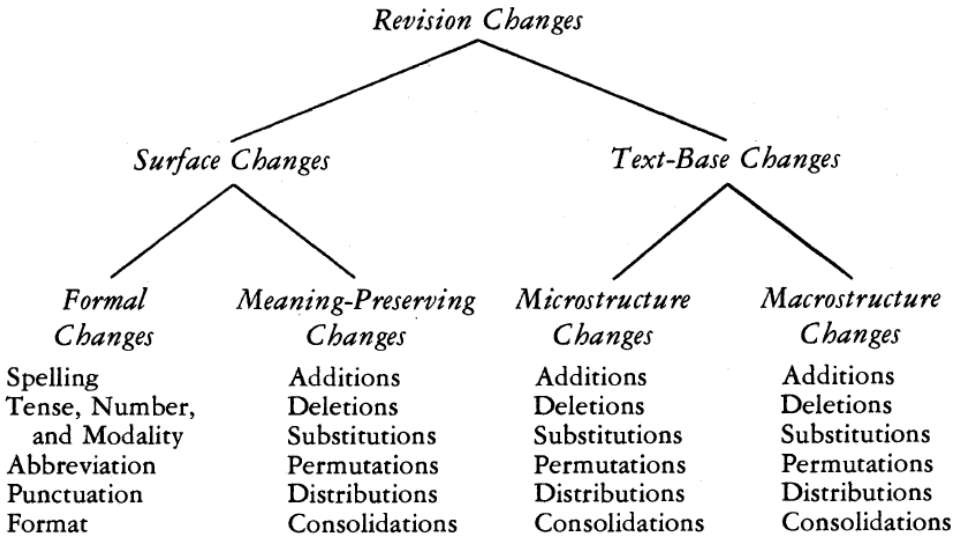

Figure 2.2. Taxonomy of revisions changes from Faigley and Witte (1981) This figure shows the codes for surface and text-based revisions.

Surface changes can be formal changes, such as spelling or formatting changes, or meaning-preserving changes, such as additions or substitutions. A meaning preserving change

does not change the overall meaning, such as adding a word, "the ∧ ^{green} fish." Text-based changes can be at the micro or macrostructure level. Macrostructure changes are so significant a summary of the writing would have to be altered from one draft to the next. Microstructure changes are meaning changes that would not change a summary, but still change the meaning of some part of the text. Meaning preserving, microstructure, and macrostructure changes can be additions, deletions, substitutions, permutations, distributions, or consolidations. Their taxonomy was designed using the revisions of six inexperienced undergraduates, six experienced undergraduates, and six expert adult writers. They refined the taxonomy eventually obtaining 90% agreement by eliminating elements that the raters were unable to consistently code.

Another useful method for analyzing transformations was introduced by Allal (2000). She developed a system for coding transformations when working with fifth and sixth graders (see Table 2.1). She coded each unit, which is an observable difference between two versions of a text, along four dimensions:

Table 2.1 System for coding text transformations from Allal (2000)

level of language	word, group, sentence, text
type	addition, deletion, substitution, rearrangement
object	semantics (lexical variations, changes of meaning) text organization (operations of segmentation, connection, cohesion) spelling (both lexical and grammatical aspects)
relationship to language conventions	conventional transformation correctly or incorrectly carried out, optional transformation not required by language conventions

This system captures the (a) level of language, (b) type of transformation, (c) object of transformation, and (d) relationship to language conventions providing a fuller picture of students' revision processes. One of the advantages of this system is the code for the relationship to language conventions. This provides data about the effectiveness of the transformation—if the transformation is necessary, does it fix the error, or is it an optional change? Other research has

captured if a revision is positive, negative, or neutral (e.g. Crawford, Lloyd, & Knoth, 2008), but the additional analysis of whether or not it is necessary is unique. By capturing this level of detail about the transformations, researchers gain further insights into the effect of students' revisions.

Both systems of analyzing revisions have been successfully used by researchers to delve into the revisions of writers. The age of the participants in the initial research shaped the focus of the tools as well as the complexity. Faigley and Witte's (1981) taxonomy has shaped how researchers think about revisions today, and Allal (2000) continues to move the conversation forward by simplifying some aspects while adding new layers about the object of transformation and the necessity of the change.

Adults and children are more likely to focus on surface features when revising their writing (McCutchen, 2006). Students often enter the revision processes with the goal of fixing these surface errors instead of rethinking the concept or flow of their writing (Flower et al., 1986). In research with fifth and eighth graders, the majority of revisions took place at the word (40%) or phrase level (25%) (Crawford et al., 2008). Upper elementary and middle school students also tended to make low-level transformations such as additions, substitutions, and deletions and rarely rearranged text (Allal, 2000; Chanquoy, 2001; Crawford et al., 2008; Dix, 2006). Overall, making macrostructure changes to a text requires a high-level of expertise and support. The majority of revisions are surface changes, which do not affect the overall quality of the text.

Few studies examine the effects of revision on quality. In some studies, researchers have examined the quality of individual transformations. In a case study with four sixth grade girls, only 4% of the two high achieving girls' changes were incorrect, while 18% of the two middle achievers' were incorrect. In a large-scale study with fifth and eighth graders, 60% of the

revisions were an improvement, while 20% were negative, and 20% were neutral. When provided with instruction in revision, an experimental group of sixth graders increased the number of revisions and made more meaning-changing revisions; however, they still did not improve the overall quality of their texts (Fitzgerald & Markham, 1987). Other researchers have also found that the amount of revision does not necessarily correlate with text quality (Bereiter & Scardamalia, 1987; Cochran-Smith, 1991; Fitzgerald & Markham, 1987). By determining the effect of revisions, researchers can better understand the place revisions have in teaching developing writers.

First to Fourth Grade Students' Transformations

The text transformations of students from first to fourth grade are affected by their transcription abilities, making them a logical group to examine. The Common Core State Standards call for second graders to revise texts, which should lead to an increased emphasis on revision in the primary grades. Three quarters of primary grade teachers reported that they revise with their students or teach about revision at least several times each month making it essential to understand how young children revise (Cutler & Graham, 2008).

Research on revision with students' written texts provides evidence that younger students are able to revise their own texts. Like older students, younger students tend to make surface changes to their texts (Chanquoy, 2001; Seawel et al., 1994); however, they are capable of making macrostructure changes (Dix, 2006). Two studies provide examples of high quality research about young children's revision processes.

A strong descriptive study was conducted by Dix (2006). She examined the revision practices of nine, eight to ten year old students from New Zealand. Children wrote and revised a poetic and a transactional piece of writing. After the first draft and the published draft, the

researcher interviewed the students to find out what changes they made and why. By conducting the interviews after they finished writing, the students' cognitive capacity was not diminished during the writing process.

The revisions were analyzed using a version of the taxonomy by Faigley and Witte (1981), adapted to younger students. The majority of the revisions students made were surface changes, correcting spelling and punctuation. All of the students made at least one surface change addition, deletion, and/or substitution. These students even made microstructure changes: all made at least three additions and most of the students had a microstructure deletion, substitution, and/or restructuring. While young children's revision processes are thought to be limited to lower-level changes, in this sample three of the students made macrostructure changes to their texts. One student added a section called handy hints, another deleted a section due to time constraints and concern over having to draw an owl, a final student restructured a poetic text. Typically, elementary students are assumed to have limited knowledge, but these students' interviews provide evidence of advanced cognitive awareness of revision processes.

Through interviews conducted in the course of the study, students revealed a deep understanding of revision. Students reported that they continuously revised their texts to make them stronger. They talked about making changes to make their writing "more accurate" or "because it didn't sound right." These young students were capable of making advanced changes. Emily made a microstructure restructuring change to her poem "Anger." In her first draft she wrote, "The sound of thunder and lightning." The second draft she added, "The sound of crashing thunder and sharp lightening in crashing storms." In the final piece, she made further changes, "The sound of crashing thunder and sharp lightening in booming storms." Emily continued to revise and refine her piece through multiple rounds of revision. Third to fifth

graders are cognitively aware of the revision processes and can make meaningful revisions to their texts.

One of the strengths of the Dix (2006) study is her use of interviews to capture the thoughts and reasoning of the students. With such a small sample—nine students—she was able to provide detailed information about the types of revisions these students were capable of making, as well as their decision processes. Her careful analysis and use of examples of students' writing provide valuable insights into elementary students' revision processes.

Another exemplary study with elementary students was conducted by Chanquoy (2001) with sixty third to fifth grade French students. Children participated in each of three conditions: (R1) online revision, where they simultaneously wrote and revised their texts; (R2) after writing revision; or (R3) postponed revision, where they revised the following day. She analyzed the frequency of each type of revisions per 100 words based on Faigley and Witte's (1981) taxonomy, length of text, frequency of surface errors in the text per 100 words, and percentage of remaining uncorrected formal errors. Chanquoy (2001) used a RM ANOVA to determine the effect of grade and condition. A separate ANOVA examined type of revision (surface or meaning), by grade-level, by revising condition. Finally, she conducted a qualitative analysis to explore the types of errors and provide a more in-depth analysis of the types of revisions.

At each higher grade, children wrote significantly longer texts. As the length of the text increased, children made more errors. The revising condition significantly affected the length of the text as well; children wrote the shortest texts when revising while writing. Across conditions, children made significantly more surface revisions than meaning revisions. Third graders made significantly more revisions when revision was postponed for a day.

A strength of Chanquoy's (2001) study is the examination of remaining errors after revising. She found that the timing of revision affected the number of errors remaining after revising. When revision was postponed for a day, students left the fewest errors in their writing. This analysis provided insights into whether students stopped revising because there was nothing left to correct or because they quit revising.

Dix (2006) and Chanquoy's (2001) work failed to include an analysis of the discussion of the quality of the revisions or the students' written products. Do the revisions strengthen the piece? Is the quality of the final product better than the initial draft? What is the overall effect of the revisions? While these pieces provide evidence that young children are capable of revising, even making advanced revisions such as macrostructure changes to texts, they fail to evaluate if these changes improve the quality of the writing. While some research with older students has captured the effect of individual revisions, determining if the change was positive, negative, or neutral, few studies evaluated the overall quality. Researchers need to analyze the quality of students' writing before and after revising. Without analyzing the quality of the final text it is impossible to determine the effectiveness of the revisions.

Digital Revisions

Computers can support writers' revision processes. The affordances of digital writing are uniquely suited to revision (Daiute & Kruidenier, 1985; Daiute, 1983; MacArthur & Graham, 1996; McCutchen, 2006). If the initial text is written on a computer, recopying after revising is not necessary (Daiute, 1983). Young children hesitate to make revisions to their handwritten texts because they look messy (Daiute, 1983). Computers can ease revision and can encourage writers to experiment and view the writing process as dynamic. Digital texts can be moved and deleted with ease. Computers eliminate the spatial and aesthetic barriers that impede revision.

Spelling and grammar checks provide support for revising. Children do not have to worry about making their text fit on the page or how to insert additional words or ideas into their texts. These affordances make computers a useful tool for teaching the revision processes to students. Because of the prevalence of word processing with older students, some studies have focused on how students revise on the computer. While the familiarity of the medium and the age of the students makes direct comparisons to first to fourth graders impractical, these findings shed light on the utility of word processors as a writing tool. A detailed discussion of these findings is relevant because of the small number of studies using computers for revision with students fourth grade and younger.

Computer Revisions for Fifth Grade to Eighth Grade.

Research with sixth and eighth graders revisions using the computer and paper has been inconsistent (Grejda & Hannafin, 1992; Joram et al., 1992; Owston, Murphy, & Wideman, 1992). While one study found the final computer texts were of higher quality than the paper and pencil texts after they were revised (Owston et al., 1992), two studies found no change in the overall quality of the texts as a result of revision or the medium used (Grejda & Hannafin, 1992; Joram et al., 1992). Using a computer did affect the number and types of revisions students made in one study (Grejda & Hannafin, 1992), but no significant difference was found in another (Joram et al., 1992).

When students were taught revision strategies on the computer and asked to revise texts using the computer, they inserted more words and sentences (Grejda & Hannafin, 1992). Students also corrected more sentence fragments and run-ons. These conflicting studies indicate a need for more research in this area. Is instruction the key factor? Grejda and Hannafin's (1992) study compared how eighth graders were taught to revise, using the computer or paper, and how

they practiced these skills. When one of the groups was asked to transfer these new computer revision skills to paper revision, the result was their paper revisions did not improve. Joram et al. (1992) found no significant difference in the quality or creativity of the overall writing or the number or type of revisions. A key difference between these two studies is the instruction that was provided to students in the Grejda and Hannafin (1992) study, indicating instruction could be a contributing factor when examining revision processes in different mediums. Is the medium unimportant? Does the amount of experience students' have with the medium effect the outcomes? All of these questions should be addressed in future studies.

First to Fourth Graders Digital Revisions.

Research about revision using computers has yielded mixed results with younger students as it has with older students. Overall the research demonstrates that younger students are capable of using computers to revise texts, but further research is needed to determine whether or not it is beneficial. The small number of studies and the varied quality makes reliable conclusions impossible.

In a small descriptive study with third and fourth graders, Seawel et al. (1994) examined the differences in the quality and revisions of students' typed and handwritten texts. The study took place over four weeks. They counted the number of revisions and number of words. The researchers found that 100% of third grade students (N=8) wrote longer texts on the computer than on paper, while 83% of the fourth grade students (N=6) wrote longer paper texts. Interview data provided insights into this discrepancy. Third grade students reported that their hands were tired when they wrote on paper, and that did not happen when they typed on the computer. Seventy one percent of third and fourth grade students reported that they preferred to revise using the computer rather than paper. Further, the authors claimed that it was possible that the

fourth grade students were more fluent writers and able to write by hand more quickly than on the computer. Another study, which was discussed previously, was conducted by Fletcher (2001) with eight second grade students who handwrote and then revised three book reviews on a computer. The researcher found that the students corrected more errors when using the word processor alone than when using the editing software. His findings are suspect because he only analyzed three book reviews. In both of these studies there are limitations due to the small sample, lack of analysis of the types or number of revisions, and systematic analysis of quality.

A strong study about revision with elementary students using word processors was conducted by an Italian researcher (Nuvoli, 2000). He focused on the revisions of 56 students from second to fifth grade. Pairs of students rewrote the ending of a fairy tale and revised their text over three sessions using the computer. He found that the students added more words and used more adjectives each time they revised their text. Also, students corrected a significant number of errors between their first draft and the second draft. These students were able to use the computer to improve spelling and content. The quality of descriptions of the characters significantly improved from the first to the final draft, but there was not a significant improvement in the quality of the descriptions of the environment or situation. This study provides evidence that when paired with instruction on revision, digital writing can have a positive impact on students' revision and in some cases even improve the quality of writing.

Primary grade students have been able to successfully use word processing programs with writing supports to improve the quality of their writing (Englert et al., 2004; Holdich, Chung, & Holdich, 2004). In a study with first and second graders, TELE-Web was used to scaffold students writing using prompts that were changed with each writing task, a spell checker, a text-to-speech tool that could read the text back to the student, and the option to share

their writing with other students for feedback (Englert et al., 2004). When using the TELE-Web tools to support writing, children included more introductions and wrote significantly higher quality texts according to the holistic rubric than when writing on paper or using only a word processor. In a study with third graders, students wrote using a program called HARRY to support them while revising (Holdich et al., 2004). While writing the original text, students were encouraged to revise; during the revision phase, grammar and style were analyzed and the program suggested ways to edit the text. This case study provides an overview of four students' use of the tool and the improvements they made to their texts. While each approached writing differently, all of their writing was improved. For example, one child worked on varying the way he started his sentences, another added more interesting vocabulary. Tools that support the writing process can enhance the revision processes for primary grade students.

Quality of Writing

Analysis of Quality

Improving the overall quality of the final product is one goal of revision, but assessing the quality of writing is a subjective task. Myriad aspects of writing quality can be measured and assessed in a variety of ways. Quality can be scored using computer programs that calculate writing scores or through analytic trait scoring done by trained raters. Raters are fallible and can be influenced by the legibility and mechanics of the text (Briggs, 1970; Graham, 1999; Klein & Taub, 2005; Rezaei & Lovorn, 2010). Researchers generally define quality in varied ways. Some researchers discuss a text's "quality" separately from word count, number of clauses, or spelling (Berninger et al., 1992; Christensen, 2004; Olinghous, 2008; Olinghouse & Graham, 2009). Other researchers use the term quality more broadly and use multiple indicators to assess and describe quality (Englert et al., 2004; Fitzgerald & Markham, 1987; Glaser & Brunstein, 2007;

Jones & Pellegrini, 1996; Nuvoli, 2000). However quality is defined, measuring it can be a challenging endeavor. Quality of writing is how closely the text matches the requirements of the task. If writing a story, does the text include the elements of a story: setting, characters, plot, etc.? The developmental appropriateness of the text is important when looking at the writing of children. First graders write very different texts than high school students.

Quality is used as an indicator in many studies about writing (e.g. Berninger & Swanson, 1994; Jones, 1994; Jones & Pellegrini, 1996; Olinghous, 2008; Olinghous & Leaird, 2009). Analyzing revision without examining the quality of the product fails to capture the ultimate goal of revision: to strengthen and improve the writing. By examining the quality of the written product before and after revising, the effectiveness of the transformations can be determined. Effective revision is a strategic action that is adapted to the necessities of the task (Flower et al., 1986). To be deemed successful, revision must improve the quality of the final product, making it better fit the demands of the task and support the readers' understanding. A wide range of research can provide insights into assessing the quality of young children's writing, from research testing the validity and reliability of a specific rubric to studies about young children's digital writing.

Some research about revision fails to capture the quality of the writing (e.g. Chanquoy, 2001; Dix, 2006). Other studies have found that the number of revisions students make does not necessarily improve the quality of writing (Cochran-Smith, 1991). Examining the quality of texts becomes even more important when comparing different treatments or mediums. Research with eighth graders demonstrated no significant difference in the quality of texts when revising on a computer and on paper (Joram et al., 1992). In an experimental study where sixth graders were trained to revise texts, the quality of the experimental texts was significantly higher than the

control group (Fitzgerald & Markham, 1987). When computers were embedded in classroom instruction, Owston et al. (1992) found that eighth graders' digital texts were higher quality than handwritten texts. These findings demonstrate the importance of assessing the quality of writing and the potential benefit of instruction and word processing on students' revisions. Unfortunately, the lack of data about the effect of revision on the quality of young students' writing is disappointing.

One challenge when evaluating the quality of written texts is the effect of rater bias. Unlike solving an addition problem, when writing, there is no one right answer. Any number of texts can fully answer the question and look very different. Rezaei and Lovorn (2010) describe how the mechanics of writing, such as spelling and grammar can influence raters' quality scores, with fewer errors leading to higher scores. Even when the quality of the content is the same, researchers have found that raters award students with more legible writing and fewer spelling or grammatical errors higher scores on content (Briggs, 1970; Klein & Taub, 2005; Rezaei & Lovorn, 2010). In a unique study with sixth grade teachers, researchers asked teachers to score nine essays that initially received the same score of 80% (Klein & Taub, 2005). Then, the researchers rewrote nine of the essays keeping all content and mechanics the same. The writing tool varied: pencil, pen, typewriter with a worn ribbon, and word processor with clear font. The handwritten pieces were either highly legible or written with poor penmanship. Klein and Taub (2005) found that although the initial scores were the same for all nine writing pieces, the new scores varied greatly. Teachers rated the more legible pieces, handwritten and typed in a clear font, by nearly 8 points higher than the initial score; the more difficult to read pieces scored as much as 12 points lower than the legible texts. This indicates that students with poor penmanship may be marked down because of their handwriting abilities. To control for rater bias some

studies have students' writing typed with spelling and grammatical errors corrected before content is scored (Graham et al., 1997; Olinghouse & Graham, 2009; Purcell-Gates, Duke, & Martineau, 2007). This allows the researchers to determine the quality of the written content without penalizing students for legibility or spelling errors.

Quality Scoring

Rating scales and rubrics are common tools used to assess the quality of students' writing. The three main types of scoring are holistic, primary trait, and analytic (Huot, 1990). Holistic scoring is the fastest and easiest way to score students' written texts. Raters give each paper a general score for the text, typically based on a scoring guideline or anchor texts. While not as reliable as some other scoring methods, holistic scores are highly correlated with analytic scores. Holistic scores are widely used in research about children's writing, revision, and digital writing (e.g. Chambless & Chambless, 1994; Grejda & Hannafin, 1992; Jones, 1994; Olinghous, 2008; Saddler & Asaro, 2007). These studies use holistic scores as a quick gage of the quality of students' writing. While holistic scores may provide insights into children's writing, their use is limited. For example, if a child has poor spelling and mechanics, but good content, the score is the same as a child who has good spelling and mechanics, but poor content. Differences in scores cannot be examined because each text receives only one score.

For the primary trait scoring, the traits of the specific genre of writing are identified and a scoring guideline is created. For example, Purcell-Gates et al. (2007) studied the effects of teaching second graders to read and write genre specific texts. To determine the quality of the students' compositions, they used different scoring guides designed for each type of text. The features of the procedural text included: has statement or goal; includes methods/procedures/steps; has an explicit clear description of materials; and others. Each of

these features received a score from zero, does not use this feature, to five, uses this feature effectively to orient the reader to the procedure or to help the reader choose the procedure. Primary trait rubrics are expensive to score due to time and rater training, limiting their widespread use in research (Huot, 1990). The strength of primary trait scoring is the ability to dig deeper into students' scores. Researchers can see the differences between students based on each primary trait, providing further insights into students' writing, not just an overall impression like holistic scoring.

Analytic scoring focuses on the qualities of "good" writing (Huot, 1990). Diederich (1974) created a seminal analytic scoring guide that continues to influence research today. In his analytic rubric, individual traits are weighted based on their importance, for example, content is weighted more than spelling. In research with sixth graders, Fitzgerald and Markham (1987) modified previous analytic rubrics (Beach, 1979; Diederich, 1974) to create eight subscales: sequence, story development, organization, word choice, details, flavor, sentence structure, and punctuation. Each could receive one to six points. Another common tool to examine writing quality is the Weschler Objective Language Dimensions (WOLD) written expression subscale (Rust, 1996) (e.g. Connelly et al., 2007; Walter & Connelly, 2010). This tool has six criteria that can be scored from one to four with a potential of 24 points. Students receive scores for ideas and development; organization, unity, and coherence; vocabulary; sentence structure and variety; grammar and usage; and capitalization and punctuation. Analytic rubrics are capable of capturing a wide range of writing quality, from content to mechanics of writing. Many researchers have taken advantage of the all-in-one nature of analytic rubrics (Christensen, 2004; Connelly et al., 2007; Englert et al., 2004; Fitzgerald & Markham, 1987; Glaser & Brunstein, 2007; Jones & Christensen, 1999; Walter & Connelly, 2010). Analytic rubrics make it possible for researchers

to use only one quality indicator and be confident that it captures variations between texts. The range of data that analytic scoring can capture allows researchers to delve into how technology or revisions affect the quality of students' writing.

The Writing What You Read (WWYR) rubric was designed to assess first to sixth grade students' narrative writing (Gearhart, Herman, Novak, Wolf, & Abedi, 1994). WWYR narrative rubric assesses the features of narratives: theme, character, setting, plot, communication, and overall effectiveness. The researchers tested its reliability and validity against another rubric and found that, with training, raters could obtain reliable scores (reliability level of .75) with the use of two raters on all but the WWYR setting subscale. The strength of the WWYR rubric is that it includes both a holistic score and five analytic scores to determine the overall quality of elementary students' narrative writing. Stories have specific elements and using a rubric that captures these features allows for a better representation of students' narrative writing ability. This scoring system focuses on the content of students' work. Researchers can combine this with other quality indicators to examine the mechanics of writing.

Englert et al. (2004) used three rubrics to examine the quality of first and second graders writing (for a full description of this study refer to "Digital Writing with Young Students"). The first rubric scored writing conventions, such as spelling, capitalization, and contextual language. The primary trait scoring looked for features such as title, introduction, details, etc. The final rubric examined word count, number of sentences, and idea units. After training, the raters were able to obtain 90% interrater agreement on all three rubrics. All of this data provided the researchers with a full picture of students' capabilities. As a result, they were able to determine that using a word processor with support gave students a significant benefit over writing with a word processor alone or writing with pencil and paper.

Developing writers are only beginning to master conventions, which generally are taught over time. Developing fluency and focusing on content can empower young writers (Graves, 1983; Ray & Cleaveland, 2004). By separately scoring students' written content and conventions such as spelling, researchers can determine where a specific intervention or teaching strategy makes an impact. Some analytic rubrics lump together conventions and content, which makes it impossible to tease out subtle differences between students (e.g. Christensen, 2004; Fitzgerald & Markham, 1987; Glaser & Brunstein, 2007). Rubrics can never evaluate the full range of a student's writing idiosyncrasies or distinctive understandings (Rezaei & Lovorn, 2010). Scoring must be tailored to the goals of the research and appropriate for the age of the students.

Other Quality Indicators.

Word count provides insights into the quality of students' writing. Research has shown a significant relationship between word count and the overall quality of writing for second and fourth grade writers (Glaser & Brunstein, 2007; McCutchen, 2000; Olinghous & Leaird, 2009). Word count is easy to capture and can provide a quick, reliable snapshot of the quality of students' writing. Word count has been used as a quality indicator in many studies with elementary writers (e.g. Barrera et al., 2001; Chanquoy, 2001; Glaser & Brunstein, 2007; Jones, 1994; Jones & Pellegrini, 1996; Olinghous, 2008; Olinghous & Leaird, 2009). Word count is also correlated with handwriting fluency in the primary grades (Berninger et al., 1992). Raters are biased towards longer texts giving them higher scores (Klein & Taub, 2005), making it an important factor to consider when evaluating children's writing. While word count is a limited assessment of quality, when used as one of multiple indicators it can provide insights into the overall quality of a writing piece. Its strength is the ease of calculation; any word processing program can provide a simple word count for a given text.

Another quality indicator is lexical density. It is the proportion of lexical terms, or content words, in a text, the higher the lexical density, the higher the text complexity (Halliday, 1989). Spoken language is less lexically dense, while written texts tend to be lexically denser. Jones and Pellegrini (1996) explain the utility of using lexical density as a quality indicator for primary grade students' writing, particularly with regards to digital writing. They argue that computers could lessen the cognitive demands of writing and the ease of revision could increase the length and quality of texts. Their research found first graders' digital texts were significantly more lexically dense than their paper texts. Lexical density can be calculated using a variety of computer programs, making it simple to calculate and a reliable measure of quality. Lexical density has been used to assess the quality of primary grade students' writing (Jones, 1994; Jones & Pellegrini, 1996).

Calculating the percent of words spelled correctly in children's writing is another critical quality indicator when evaluating the utility of word processing on writing, especially with the availability of spell check. Capturing students' spelling ability in context is an authentic measurement of their skill. Olinghous (2008) and Olinghous and Leaird (2009) captured the percent of words spelled correctly in context in her research with second through fourth graders. She found that spelling was significantly correlated with the quality of the overall text. Percent of words spelled correctly in context provides further insights into the effect word processing has on the revision processes of novice writers. Correcting spelling is an essential aspect of editing a text. Another element of spelling quality measure is word-choice accuracy. Ensuring the word is not only a real word, but the correct word provides a deeper understanding of students' writing abilities.

It is quite clear that quality of writing cannot be easily calculated, but researchers have established that quality is directly correlated with handwriting fluency, spelling, word count, verbal IQ, and word reading in primary grade students (Berninger & Swanson, 1994; Berninger et al., 1992; McCutchen, 2000; Olinghous, 2008). Calculating the correlations between various quality indicators provides researchers with an understanding of the unique variance that each contributes.

This study uses quality of writing as an indicator to help determine the effect revision has on the quality of second graders narratives using two transcription technologies, pencil and computer. By building on previous research, this study seeks to expand our understanding of revision and transcription technologies using quality as an indicator.

Gaps in the Literature

This review of research has identified several gaps in the literature: (a) the effect of cognitive load of transcription on transformations, (b) effect of transcribing technology on young students' transformations, and (c) effect of transformations on the quality of writing. This study aims to help fill those gaps by seeking to determine the effect of the cognitive load of transcription, with regards to spelling ability and writing speed, on the transformations of second grade students' narrative texts in two mediums: on paper and on the computer.

Cognitive load theory has been used extensively to study mathematics and other problem solving activities (Kalyuga et al., 2010; Paas et al., 2010; Sweller, 1988; Sweller et al., 2011). While the cognitive perspective has guided much research about writing, CLT provides a framework to understand the complexities of revision with young writers. The cognitive load of transcription, with regards to writing speed and spelling, has been used to study the quality of students' writing but not its impact specifically on revision at any grade-level. Examining the

cognitive load on paper and on the computer provides a way to control differences in handwriting and typing ability as well as spelling ability in both mediums.

Hayes (2012) identified the transcribing technology as an important aspect of writing. With computers and technology becoming increasingly prevalent in today's society, the effect of word processors and other digital writing tools on young children's writing must be fully examined. Few studies have examined the effect of digital writing with young students on revision. Research about handwriting and typing speed indicates that young children are faster at handwriting than typing. By examining the speed of writing in both mediums, this study seeks to determine if the affordances of word processing, such as the use of spell check and ability to move blocks of text, outweigh the slower typing speed. What is the effect of medium on the number and types of transformations?

Many studies about revision with young children fail to examine the effect of the transformations on the overall quality of the piece. Knowing the overall number of transformations or type of transformations fails to capture the effect of transformations on the quality of writing. By using multiple measures of quality, this study seeks to gain a fuller understanding of the effects of revision.

CHAPTER III: METHODOLOGY

Existing literature reveals a lack of research about (a) revisions of narrative texts, (b) the impact of computers, and (c) the effect of cognitive load of transcription in first to fourth grade students' written work. This study, which examines second grade students, explores the relationship between the cognitive load of transcription with regards to writing speed and spelling ability, as well as transformations of students' own narrative texts using two different mediums—handwriting and word processing. This chapter explains (a) the research design, (b) procedures, (c) hypotheses, and (d) proposed analysis of the study. Accordingly, this study sought to answer the following research questions:

1a. Is there a significant difference between the revisions second grade students make when using handwriting or a word processor?

1b. Is there a significant difference between the change in quality from the initial to final draft of second grade students' narrative texts when revising using handwriting or word processor?

2a. What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the number of revisions second graders make to their narrative texts using handwriting? Using a word processor?

2b. What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the quality of second graders narrative texts when revising using handwriting? Using a word processor?

Hypotheses

The first area of interest in the proposed research was the types of revisions made by second grade students on paper and on the computer. Little is known specifically about second grade students' revision of their own texts. This study aimed to identify types of revisions and the differences between digital and paper revisions. The researcher theorized that second grade students would primarily make surface level revisions, correcting spelling or adding a few words here or there. The computer mode could encourage more revision than on paper because of the unlimited space and available spelling tools. Another area of interest was the effect of the revisions on the quality of children's writing in both mediums: pencil and computer. Prior research had yielded mixed results concerning the ability of children's revisions to improve quality of their writing (Crawford et al., 2008; Fitzgerald, 1987; Fitzgerald & Markham, 1987; Owston, Murphy, & Wideman, 1992). By using a variety of quality indicators, this study aimed to identify potential areas that revision may improve. The researcher put forward that improved quality would be more likely in the lower-level indicators: word count, lexical density, and percent of words spelled correctly. It would be less likely that the narrative rubric scores would improve based on a single round of revisions. The researcher also proposed that the affordances of the computer may make computer revisions improve the overall quality of writing more than paper revisions. When examining the change in quality from the initial to final draft, the mode of revision may influence the quality of the final draft with higher word counts and lexical density of digital texts.

A second hypothesis was that a relationship existed between the cognitive load of writing speed and spelling with the transformations that second graders make to narrative texts on paper and on the computer. Students that were faster writers and stronger spellers would likely make

more revisions, than slower ones. The researcher predicted that although the cognitive load of writing would be higher on the computer, the affordances of the technology could lead to more transformations despite the higher cognitive load required. Digital texts would likely have more spelling changes and additions than paper texts because of the space available. The cognitive load of transcription may affect the quality of the final texts. Students with better digital transcription skills may be able to improve the quality of their texts more than those with lower digital transcription skills.

Research Design

This study used a counter-balanced randomized block design. Four intact second grade classrooms were randomly assigned to one of two conditions to control for bias: paper revisions then computer revisions or computer revisions then paper revisions. Students completed a one-time on-demand revision task using two transcription technologies: pen and word processor. The children wrote two stories on paper and revised each using either pen or Microsoft Word. Data were collected about the revisions, quality of text, and students' transcription skills, measured by writing speed and spelling ability. This research builds upon the existing research base about primary grade students' transformations and extends it with the examination of the impact of the cognitive load of transcription.

The Research Context

The Schools.

This research was conducted in four second grade classrooms in two suburban schools outside a large Midwestern city. The classrooms were in elementary public schools that serve approximately 400 students each. School 1 had three second grade classrooms that all participated in the study. School 2 had four second grade classrooms, one of which participated

in the study. The majority of the students were Caucasian (approximately 80%) and middle class with a median family income of $85,000. Data collection took place in January and February, therefore the students had half a year of writing instruction with the teachers in the study.

The district had invested heavily in professional development around writing the past three years. They worked closely with Lucy Calkins and Columbia University to improve writing workshop. Teachers received professional development throughout the school year and have the option to do work that is more extensive over the summer. Their writing workshop was based on Lucy Calkins *Units of Study* (Calkins, 2014).

In the current writing program in place through the district, children participated in various units related to process, genre, strategy, and conventions. Each writing session included a mini-lesson, followed by independent practice, and ended with a sharing time. One component of writing that was highlighted in the program is revising and publishing work. To revise, students used blue pens to make changes to their texts. When revising, students were encouraged to ask questions to see if their text was ready to be published. Revising was often completed with buddies or with teacher assistance at the end of a writing unit. The focus of revision was on making their ideas bigger, adding interesting words, and fixing spelling, punctuation, as well as capitalization. To support the children in this endeavor, the teachers provided students with a list of questions to use to guide the revision process. The students had participated in this writing program during first grade and had been exposed to revision the previous school year.

During second grade, revision was revisited throughout the year. Students had been asked to revise stories or other texts in three of the units of study before the winter break. The second grade teachers met with the researcher to identify questions for revising narratives a month before data collection began. Prior to that time teachers used a variety of questions for revising,

depending on the unit of study. The teachers determined what questions the students would ask when revising stories, and the researcher provided the typed list for all of the students' writing folders (see *Figure 3.1.* Writers' questions). After winter break in the unit prior to data collection, students wrote personal narratives. The teachers had the students use these questions during this personal narrative unit, Telling Gripping Stories.

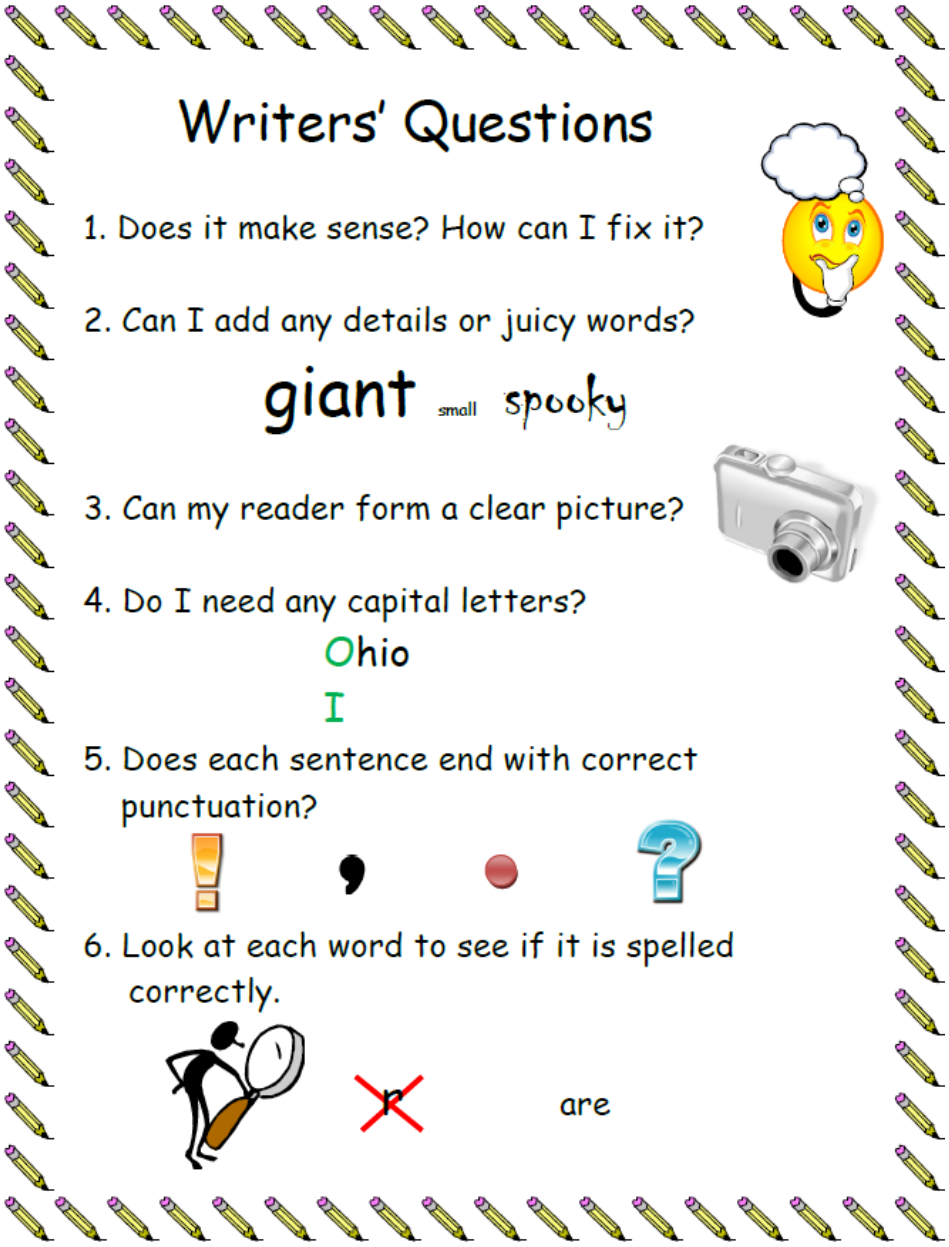

Figure 3.1. Writers' questions. This figure shows the questions the students use when revising texts.

It is essential to note that this study did not teach the students how to revise; instead, the focus of the study was solely centered on how children, who have prior experience revising, revise texts in different conditions. Classrooms using a process writing approach were selected for the research site in large part because of its focus on revision and writing processes. Specifically, conducting the study in a setting where students regularly revise and publish texts

aided in identifying characteristics of second grade level revisions in the scenarios involving students with prior experience revising.

Each of the teachers at the schools selected for this study had four computers available for use in their classrooms, as well as a laptop cart or computer lab that could be signed out for whole class activities. Their typical curriculum included playing educational games and visiting various websites. Students had not previously used the computer for composing texts at school.

The Teachers.

The teachers in this study had an average of 10.5 years of experience (the study took place midway through the year, consequently all increments are in half year units), ranging from one and a half years (Teacher 1) to 19.5 years (Teacher 4) (see Table 3.1 Teachers Experience and Qualifications). Three of the teachers had used the Lucy Calkin's curriculum for one and a half years and one teacher (Teacher 4), who had been part of the pilot program, used it for two and a half years. The teachers had all participated in a weeklong writing institute the summer before the research began and attended monthly professional development sessions. All of the teachers had undergraduate and graduate degrees in education and were considered strong writing teachers by the district administration.

Table 3.1
Teachers Experience and Qualifications

	Teacher 1	Teacher 2	Teacher 3	Teacher 4
School	A	A	A	B
Condition	Paper/Computer	Paper/Computer	Computer/Paper	Computer/Paper
Years of teaching experience	1.5	8.5	12.5	19.5
Years of 2nd grade teaching	1.5	8.5	16.5	4.5
Years using Lucy Calkins	1.5	1.5	1.5	1.5
Degree(s)	M.A. Early Childhood; B.S. Psychology and Educational Studies	M.A. Reading Education; B.S. Early Childhood	M.Ed. Education B.S. Early Childhood	M.Ed. Reading Education; B.A. Elementary Education

The Participants.

74 children, from four classrooms, participated in the study. All students in the research classrooms were invited to participate, ten students did not return consent documents or their parents' elected to have them not participate. Two additional students were excluded because they were unable to complete the tasks due to learning differences, specifically language processing issues and attention deficit disorder. Of the 74 students included the final sample, five of the students did not complete one of the revision tasks and were excluded from the analysis for that medium. Two of the students with incomplete data sets copied stories from books for the computer revision task. Two refused to write the initial draft and had nothing to revise; one refused to write for the computer task and the other refused to write for the paper task. One refused to revise his paper story. Due to these factors the number of students in the different analyses varied: (a) all of the cognitive load analyses included all 74 students; (b) any analysis of paper revision only included 72 students; (c) any analysis of computer revisions only included 71 students; (d) and any analysis comparing paper to computer revisions included 69 students (for a full explanation see Chapter IV: Final Data Set). The majority of the students are

Caucasian from middle class households, and the primary home language is English (see *Table 3.2. Ethnicity of Students*). Students ranged in age from 7 years 3 months to 9 years 1 month.

Table 3.2
Ethnicity of Students

	Number	Percent
Caucasian	59	80%
African-American	13	18%
Asian	1	1%
African	1	1%

The researcher conducted a survey (see Appendix A: Computer and Mobile Device Access and Use Survey) about the students' access and use of computer and mobile technologies. These surveys were orally administered by the researcher to individual students before they completed the Computer Activity – Text to Edit. 88% of the students had access to working computers at home and 88% had access to a mobile device they were allowed to use. Mobile devices ranged from apple devices (iPad or iPod) (42%), Kindle (24%), Tablet (23%), Cell phone (18%), and Nook (3%). Students frequency of use varied greatly (see *Table 3. 3 Frequencies of Computer and Mobile Device Usage at Home by Percent of Students*). Students were more likely to use a mobile device daily (38%), than a computer (16%). This trend continued across all frequencies, with most students using mobile devices more often than a computer. 16% of students reported they never used a computer at home, and 12% of students reported they never used a mobile device.

Table 3. 3
Frequencies of Computer and Mobile Device Usage at Home by Percent of Students

Frequency of Use	Computer	Mobile Device
Daily	16%	38%
Weekly	54%	43%
Monthly	14%	7%
Never	16%	12%

The activities students participated in varied based on computers and mobile devices as well (see *Table 3. 4 Students' Activities on the Computer and Mobile Devices at Home by Percent of Students*). Across computers (78%) and mobile devices (84%) games were the most common activities. Interestingly, 5% of students reported they wrote stories on the computer.

Table 3. 4
Students' Activities on the Computer and Mobile Devices at Home by Percent of Students

	Computer	Mobile Device
Games	78%	84%
Websites	38%	11%
Chat or Text	1%	5%
Write Stories	5%	0%
Take Pictures	1%	8%
Watch Videos	12%	19%
Listen to Music	0%	3%
Read Books	1%	8%

This survey indicates that the majority of students had access to computers and mobile devices at home, but typically they were not used for writing.

Procedures

Overview of Schedule

This study took place over seven whole class lessons and one pull out session with small groups of students (see *Table 3. 5 Schedule of Data Collection*). During the first three sessions and the pull out session, students completed the initial cognitive load assessments and received computer training. Writing and revision tasks occurred during the study's four writing sessions. The researcher provided all instruction throughout the study. Full lesson plans are included in

Appendix E. Each lesson included a script the researcher used during the lesson to ensure all students received the same instructions and opportunity to learn.

Table 3. 5
Schedule of Data Collection

Handwritten Assessments – Whole Class	Cognitive Load Assessments: • handwritten spelling assessment (WRAT4) • handwriting fluency assessment
Computer Training 1 – Whole Class	Introduction to Word Processing: • how to save a document • type text with capitals and spaces • delete text using the delete and backspace keys • use spell check • correct misspelled words that have red squiggly line with a right click
Computer Training 2 – Whole Class	Cognitive Load Assessment: • typing fluency assessment Introduction to Word Processing: • review previously introduced skills (see session 1) • copy and paste text from one section of the document to another
Computer Assessment – Pull out	Assessments: • digital spelling assessment (WRAT4) – administered in small groups • complete Computer Activity – Text to Edit (see *Figure 3.5.* Computer skills assessment – Text to edit) – administered individually • Computer and Mobile Device Access and Use Survey (see Appendix A: Computer and Mobile Device Access and Use Survey) – read by researcher to each student individually
Writing Sessions	
Writing 1	Planning and writing initial draft
Writing 2	Revising and final draft (either paper or computer)
Writing 3	Planning and writing initial draft
Writing 4	Revising and final draft (either paper or computer)

Cognitive Load Measures

Writing Fluency and Spelling Ability.

Because cognitive load cannot be directly measured, researchers must find indicators to serve as a proxy to measure the effect of working memory (WM) on a given task. In research with primary grade students, Berninger et al. (1992) examined how predictor variables (i.e. neuromotor, reading, verbal intelligence) and writing criterion measures (handwriting, spelling,

and composition quality) constrain children's writing. These variables served to indirectly measure the effects of WM of primary grade students' compositions. The researchers explain that translation requires two components—text generation and transcription. To measure transcription abilities, researchers assess writing speed and spelling ability (Berninger et al., 1992; Connelly et al., 2007; Graham & Harris, 2000; Hayes & Berninger, 2010)

To measure the cognitive load of transcription, children completed a handwriting task and a typing fluency task. The handwriting task was administered in their classroom during the initial handwritten assessments session. For the handwriting task, children used a pen to handwrite "The quick brown fox jumps over a lazy dog," (Connelly et al., 2007). Connelly (2007) found the mean number of letters handwritten by second graders was 66.8 and typed letters was 24.1. The researcher read the students the following directions, "Please write the sentence that is written at the top of the page 'The quick brown fox jumps over a lazy dog,' as many times as possible in two minutes. If you make a mistake keep going, do not make changes while you are writing. Make sure you write legibly so I can read what you have written. You may begin now." While explaining the task, the researcher modeled how to repeatedly write the sentence quickly and legibly, and demonstrated how they should write the sentence again if they finished the first sentence before time is up. The provided answer sheet for this task was formatted as a landscape page with the sentence typed at the top of the page in bold 21 point Calibri, which is the default for all Microsoft Word computers (see Appendix C: Handwriting Fluency Task). Beneath the sentence, the students had solid lines with 1.5 spacing for copying the sentence. The backside of the page had the sentence at the top and additional lines. During the assessment, the researcher and teacher monitored the students and encouraged them to keep typing if they stopped.

The typing task administration occurred during the second computer training session (see Appendix D: Lesson Plans). The task was administered in the computer lab (School A) or using laptop computers in the classroom (School B), depending on the school. For the typing task, students opened a Word document with the same sentence in 21 point Calibri on the top of the page. The researcher read the directions for the task, "Please type the sentence that is written at the top of the page 'The quick brown fox jumps over a lazy dog,' as many times as possible in two minutes. If you make a mistake keep going, do not make changes while you are typing. Make sure you type so I can read what you have written. You may begin now." The researcher again modeled to continue typing the sentence again if the students finish before time finished. During the assessment, the researcher and teacher monitored the students and encouraged them to keep typing if they stopped.

Handwriting fluency speed was calculated by counting the total number of correct letters written in the two minute period. The letter had to be in the correct location and legible. For example, if the word "brown" was written "bronw," the child received 3 of the 5 possible points. To be deemed legible to the researcher and the second rater, the letter would be recognizable alone on a page without other context clues. Typed fluency speed was calculated by the number of correct letters written in order during the two minute period.

To measure the cognitive load of spelling, children completed the spelling subtest of the Wide Range Achievement Test (WRAT) both by handwriting and on the computer (with the spell check turned on) (Wilkinson, 2006). The test was available in two versions; a different version was administered on paper and on the computer. The assessments were scored based on the testing manual, and the standardized score will be used in all analysis. The handwritten assessments took place during the initial handwritten assessments session prior to the computer

training sessions. The typed fluency assessment took place during the second computer training session, and the typed spelling assessment took place during the third computer training session in a small group.

Computer Training

In order to introduce the students to word processing, the students required additional training. The researcher provided two training sessions to each of the classes prior to beginning research, the goal of which was to introduce students to the affordances of Microsoft Word. This training gave students an opportunity to learn how to use Microsoft Word to revise their stories during the writing sessions, but was not adequate to teach typing skills.

Students each had their own computer for all study activities. The researcher and the teacher were available to assist the students as they worked on the computers. Each session focused on introducing various features of the word processing program and allowed students to practice using the tool.

Training 1. The researcher introduced students to word processing by creating a text about herself. Various skills were introduced during session 1 including: (a) saving a document, (b) typing text with capitals and spaces, (c) deleting text using the delete and backspace keys, (d) using spell check, and (e) correcting misspelled words that display the red error indicator line with a right click. Then, the children opened their own documents. The researcher created a text for each child to begin. The students' page had lines for Name and Class that the students completed. The next line had the word becuz. The word appeared with a red squiggly line (see *Figure 3.2.* Sample student page computer training session 1).

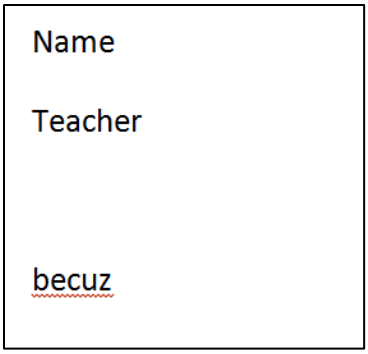

Figure 3.2 Sample student page computer training session 1. This figure shows what the student page looked like during the first computer training session.

The researcher walked the students through the process of right clicking to correct the spelling of because. This ensured that all students had an opportunity to use the spell check with guidance. Children then had the opportunity to write their own texts introducing themselves to the researcher. During this time, the researcher and the classrooms teacher walked around the room and helped students. For example, if any of the students were not using capitals and spaces, they provided additional training at that time.

At the session midpoint, the researcher asked the students to raise their hands if they had successfully corrected a misspelled word using a right click. Then, she asked the students to raise their hand if they have successfully used the backspace key. She encouraged the students who have not tried these tools to use them before the end of the period and reminded them to raise their hands if they needed assistance. At the end of the session, the researcher again asked the students if they had corrected spelling using a right click or used the backspace key. The researcher then demonstrated how to save their documents and the students saved their documents before exiting the program.

Training 2. First, students completed the digital writing fluency assessment (see above *Cognitive Load Measures* for full description). Then, the introduction to word processing

continued. The classroom teachers determined that the students should write about snow. The researcher used her own text to demonstrate.

"Snowy days are my favorite. I buld big ones and little ones. I make entire snow families in my backyard. I give them carrot noses and eyes button."

The researcher revisited the skills introduced in the previous session and introduced students to copying and pasting text from one section of the document to another. She provided students with (see *Figure 3.3.* How to cut and paste handout)*Figure 3.3.* How to cut and paste handout. This figure is the handout students used to support them while cutting and pasting. and walked them through the process with her own text.

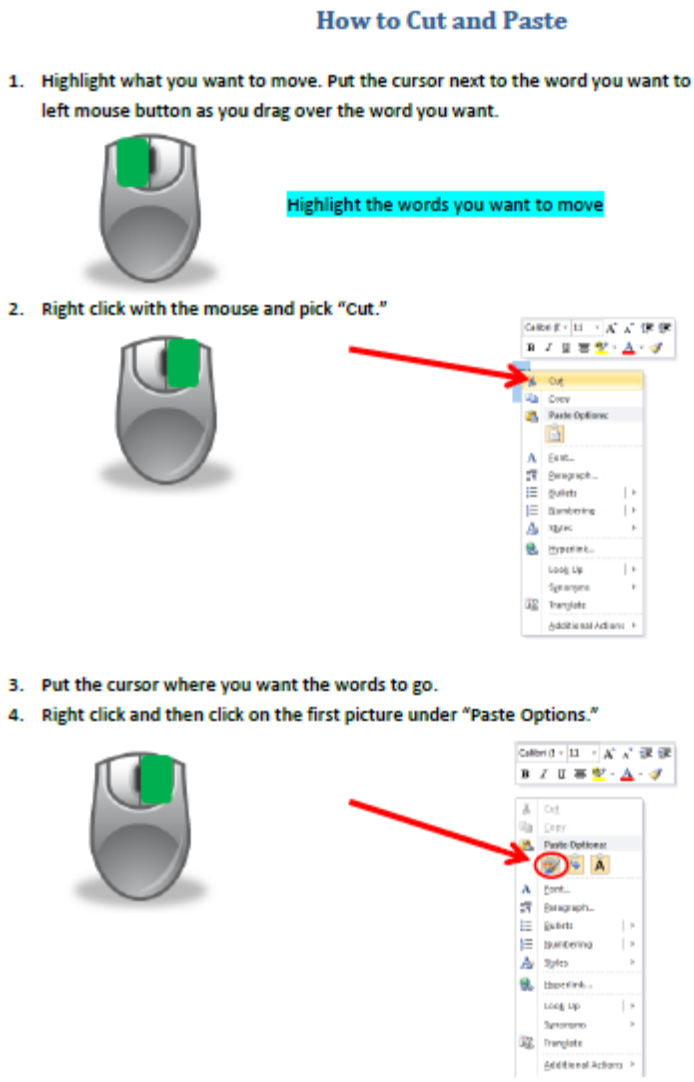

Figure 3.3. How to cut and paste handout. This figure is the handout students used to support them while cutting and pasting.

She modeled how to cut and paste "button" so it was before "eyes," as well as, move "I make entire snow families in my backyard" to before "I build big ones and little ones." Then, the students had the opportunity to cut and paste on their own documents. Their pages for the day had the Teacher line before their Name line. So the researcher walked them through the process of cutting and pasting the Name line (see *Figure 3.4* Sample student page computer training session 2.).

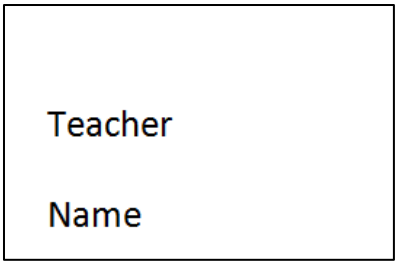

Figure 3.4 Sample student page computer training session 2. This figure shows what the student page looked like during the second computer training session.

The children then wrote their own texts based a prompt chosen by the classroom teachers: "Snow - What do you like about snow? What don't you like about snow? What do you do on snowy days?" When students began writing, the researcher again reviewed how to open a document. The researcher and the teacher walked around the room and to see if any of the students need additional support.

Halfway through the session, the researcher asked the students to raise their hands if they had successfully copied and pasted part of their text to another part of the page. If no one had yet attempted this function, then the researcher would review how to copy and paste text. She then encouraged the students to try to copy and paste a single word or sentence. Children then returned to writing their texts. At the end of the period, the researcher asked children by a show of hands who had corrected the spelling of a word using a right click, used spell check, and copied and pasted a word or sentence. She had the children save their documents.

Small Group and Individual Computer Assessments. Because of the students' lack of computer experience, it was necessary to administer the final assessments in a small group and individual setting. This ensured that no data were lost to a child accidentally closing the program and/or deleting their work. This session began with the administration of the spelling assessment from the WRAT4 (see below *Cognitive Load Measures* for full description). Students were given the digital spelling assessment in small groups of three or four. The spell check was turned on

during this assessment. One of primary affordances of the word processor is the ability to have spelling assistance. By measuring the effect of the spell check feature on students' spelling, the researcher obtained a more accurate assessment of the students' digital spelling ability. After the assessment was completed, children saved their work.

Finally, individual students were pulled to complete a computer skills task and were interviewed by the researcher about their access to technology. To determine how many of the tools the students were able to use, they were asked to revise a text written by the researcher. She began the session by reading the story to the students (see *Figure 3.5.*Computer skills assessment – Text to edit). This text was tested for readability using Microsoft Word. The Flesh-Kincaid readability level was 2.3, making it an early second grade reading level, which was appropriate for the January data collection. Then, she read each direction one at a time to the students (see *Figure 3.6.* Directions for text to edit assessment), while the students completed the task. The researcher filled out the Computer Skills Checklist (see *Figure 3.7.* Computer skills checklist) to capture if the students were able to complete the task independently, with support, or, were unable to complete task. To score independent, the child had to complete the item with no assistance. To receive a score of with support, the researcher could provide verbal directions and point to how to complete the item. Students received an unable score if they were unable or refused to complete the task. This assessment provided insights into the students' ability to use the various affordances of the computer, from cut and paste to saving a document independently or if they continued to need support as they used the computer. The researcher also captured the students' editing skills by using the Editing Skills Checklist (see *Figure 3.8.* Editing skills checklist). The researcher coded each word that the students should have corrected the spelling with a score of independent, attempted but incorrect, or unable. This provided insights into the

students' ability to edit texts on the computer. To complete the task, children had to capitalize the beginning of three sentences, correct the spelling of three words, cut and paste one sentence in the story, and save their final document.

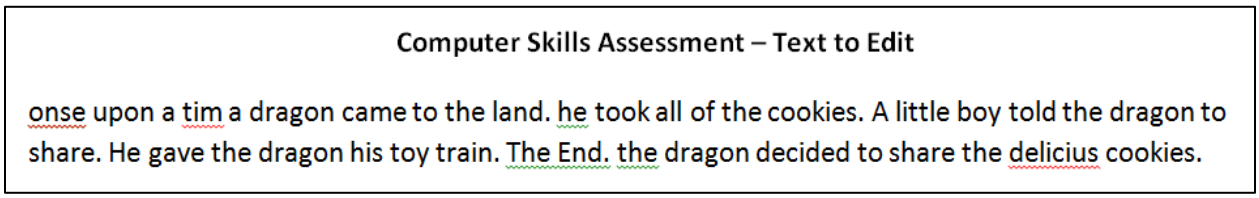

Figure 3.5. Computer skills assessment – Text to edit. This figure shows the text the students will edit for their computer training session.

Directions for Text to Edit Assessment

1. Make sure every sentence begins with a capital letter.
2. Fix the spelling of any misspelled words.
3. Cut and paste the sentence "The End." So it is after the sentence, "The dragon decided to share the cookies."
4. Save your document.

Figure 3.6. Directions for text to edit assessment. This figure shows the directions for the students to use to correct the text.

Computer Skills Checklist

		Independently	With support	Unable
Capital Letters	Uses shift key			
	Uses caps lock			
Spell Check	Identify misspelled words			
	Right click to get list			
	Select word			
Cut & Paste	Highlight words			
	Right click			
	Select cut			
	Put cursor in correct location			
	Right click			
	Select paste			
Save File	Click on File			
	Click on Save			
	Click on Save Icon			

Figure 3. 7 Computer skills checklist. This figure shows the checklist used to capture how children completed the Computer skills assessment – Text to edit.

Editing Skills Checklist

		Correct	Attempted, but incorrect	No attempt
Corrected spelling	Once			
	Time			
	Delicious			
Made first word capitalized	Once			
	He			
	The			

Figure 3.8 Editing skills checklist. This figure shows the checklist used to capture how children completed the Computer skills assessment – Text to edit.

Revision Task

All of the children wrote their initial stories using paper and pencil. This was the typical way these students wrote during writing workshop. By keeping the method of initial composition constant, the researcher controlled the task to minimize the effect of typing speed or novelty distractions that could influence the quality and length of children's original stories. Then, the students participated in both conditions and revised the texts either using paper and pen or word

processor. For the word processing condition, the researcher typed the children's texts into the word processing program preserving all of the students' errors, mirroring the procedures used by Grejda and Hannafin (1992). Classrooms were randomly assigned to one of two conditions:

- Paper/Computer - Revise the first story using paper and a blue pen; revise the second story using Microsoft Word
- Computer/Paper - Revise the first story using Microsoft Word; revise the second story using paper and a blue pen

These conditions provided insights into the revision processes of second grade students. The paper/computer and computer/paper groups were counterbalanced to negate any influence the order the intervention was administered could have on the findings. Each story was planned, written, and revised over the course of two 45-minute writing sessions, during their regular writing time, for a total of four sessions. The researcher provided all instruction during these lessons. The students were asked to create a story to be shared with the other second graders at a writing celebration. This provided an authentic purpose for writing, which motivates students and leads to a higher quality writing product (Cameron & Hunt, 1996). The sessions were taught in the following order:

- Writing 1: Planning and Writing Initial Draft
- Writing 2: Revising and Final Draft Story 1: Either Paper or Computer
- Writing 3: Planning and Writing Initial Draft
- Writing 4: Revising and Final Draft: Either Paper or Computer

Writing 1 and 3: Planning and Writing Initial Draft Sessions

During the first and third writing sessions, the students wrote the first drafts of their stories. The researcher introduced students to the writing task and provided students with a

planning sheet (see *Figure 3.9.* Writing planning sheet). The teachers together selected an appropriate graphic organizer to scaffold the students' writing. The students often used a graphic organizer to guide their writing. The researcher explained the graphic organizer and provided a demonstration of how to fill out the planning sheet with her own story. Then, she reviewed where authors get ideas and posted the page on the projector while they filled out their own graphic organizers (see *Figure 3.9.* Writing planning sheet). Students had 8 minutes to complete the planning page. If the students finish early, then they could begin to draw an illustration for their story. At the end planning time, the researcher explained that the students would have 25 minutes to write their first draft of the story. The researcher gave the students a 5 minute warning before the end of the writing period. While the students were writing, the researcher reminded the students that they wanted to create interesting stories for the writing celebration. If a student finished before the end of the period, the researcher asked if he or she wanted to add anything else to their story.

Story Elements Planning Page

Name_____

Teacher _____

Plan your story.

Title	
Setting: Where? When?	Characters:
Problem:	Solution:

Figure 3.9 Writing planning sheet. This figure shows the graphic organizer students used to plan their writing.

Figure 3.10. Where you can get story ideas. This figure shows the page with ideas for student writing.

Revising and Final Draft Lessons: Either Paper or Computer

During the second and fourth sessions, the researcher taught a lesson on revision. The researcher provided the students with a list of the revision questions the teachers typically use during revising (see *Figure 3.1.*Writers' questions). The researcher modeled revision in the same medium the students were revising their stories with—paper or computer.

This session varied based on the condition. For the students that revised using the computer, the researcher typed their texts into Microsoft Word. All of the students' original spelling and punctuation were preserved. The researcher briefly reviewed how to open a document for the computer revision activity. To identify revisions on the computer, the draft was compared to the final story using Microsoft Word. A merge was completed to highlight changes between drafts. For the paper revision tasks, the students made revisions in blue pen. Children could finish their illustrations after they finished revising.

After the initial two sessions, lessons repeated a second time. The lessons remained the same except during the revision lesson students used the other writing medium.

Scoring Transformations and Quality

Types of Transformations.

To identify the types of revisions that second graders made to narrative texts, prior research on revision was used to guide the analysis (Allal, 2000; Allal et al., 2005; Chanquoy, 2001; Crawford, Lloyd, & Knoth, 2008; Dix, 2006). Transformation coding was based on the work of Allal (2000) and Allal, Lopex, Lehraus, and Forget (2005) with fifth and sixth grade students (see *3.6 System for coding text transformations: Adapted from Allal (2000)*). While these students are older than those in the present study, similar transformations coding were used in research about third grade students by Dix (2006). Definitions of codes were modified from Crawford, Lloyd, and Knoth (2008) as well as Allal (2000) because together they provided the most easily understandable coding description. Each transformation was coded at four different levels: (1) level of language affected by the transformation, (2) type of transformation, (3) object of transformation, and (4) relationship to language conventions.

Table 3.6
System for coding text transformations: Adapted from Allal (2000)

Level of language affected by the transformation	
Punctuation*	Includes beginning, middle, and ending punctuation, and correct punctuation of abbreviations and titles.
Word	Includes proper nouns, abbreviations, etc.
Group	As few as two words should be scored as a "group."
Sentence	Must contain subject and predicate; correct punctuation unnecessary.
Text	A group of sentences.
Type of transformation	
Addition	Any unit may be added.
Deletion	Any unit may be deleted.
Substitution	Most often punctuation and words will be substituted.
Rearrangement	Phrases, sentences, and paragraphs will be rearranged.
Object of transformation	
Semantics	Lexical variations, changes of meaning
Text organization	Primarily operations of segmentation, connection, cohesion
Spelling	Both lexical and grammatical aspects
Relationship to language conventions	
Conventional transformation correctly carried out	Required by the rules of spelling, syntax, and punctuation that no variation is accepted by authoritative references (*Oxford English Dictionary*) and is correctly carried out
Conventional transformation incorrectly carried out	Required by the rules of spelling, syntax, and punctuation that no variation is accepted by authoritative references (*Oxford English Dictionary*), but is incorrectly carried out
Optional transformation not required by language conventions	Change not required by rules of spelling, syntax, and punctuation

Note: Definitions from Crawford et al. (2008) and Allal (2000).
* Punctuation added from Crawford et al. (2008).

To use the system for coding text transformations, the researcher identified a transformation a child made. Each transformation received four different codes. The first code was based on the level of language affected by the transformation. This code identified the level the transformation affected (a) punctuation, (b) a single word, (c) a group of words, (d) a sentence, or (e) a section text longer than a sentence. For example, if a child added "perfectly perfect" to describe the Barbie house, this would be coded at the group level because it was more than one word, but less than a full sentence. The level of the code was dependent on the final version of the text. This

provided the researcher with data about whether students were making changes at the word level or looking across the text to make modifications.

The second code was the type of transformation. An addition could be adding a single word, a period, or even a few sentences. Deletions could be at any level as well. Substitutions could be changing spelling, punctuation, or a sentence. To be considered a substitution, the original word or sentence had to be replaced with a new word or sentence. For a substitution, the final change was counted. For example, if a child changed "They" to "Sara, Lisa, and Jackson," it would be coded as a group change. A rearrangement required the text order to be changed. This included changing the order of a paragraph, sentence, or switching two words.

The third code was the object of transformation. Three types of object transformations were (1) semantics, (2) text organization, and (3) spelling. A semantics transformation could be a meaning change, for example, inserting the word "magical" to describe a castle. The added detail slightly changed the meaning of the text—it was not only a castle; now it became a magical castle. It also included a lexical variation such as changing the word soda to pop. Text organization transformations included segmentation, connections, and cohesion. Segmentation included inserting spaces between words, as well as inserting or changing punctuation. Connections included connecting words or sentences such as adding the word "and" or putting a comma in a list of words. Cohesion could be in referencing such as changing a proper noun to pronoun, from "Daniel" to "he" or vice versa. Another example of cohesion was the insertion of a conjunction or transition such as "but" or "then." Spelling was the final object of transformation. Spelling could be a lexical or grammatical modification such as correcting an error in tense or changing a misspelling of a word.

The fourth level of transformation was the relationship to language conventions. This level of coding captured the necessity of the transformation and determined if it was correctly implemented. One code was for a conventional transformation that was correctly carried out; these changes were required by the rules of spelling, syntax, or punctuation and were implemented correctly. For example, changing "The prince goed to the castle," to "The prince went to the castle." The word "goed" would not be correct; by changing the word to "went," a spelling and grammatical error was corrected. If the student had changed "goed" to "wented," then it was coded as a conventional transformation, incorrectly carried out. Optional transformations were not necessary. An optional transformation could be an addition; for example, changing "the princess" to "the beautiful princess," it was not grammatically or linguistically necessary.

Twenty student papers were analyzed using this initial coding scheme. While the researcher coded these papers, she took notes about the various codes and identified any potential pitfalls to interrater agreement. The researcher revised the coding scheme to ensure it was appropriate for second grade students and provided a reliable snapshot of their transformation capabilities. At this point, the researcher added "Case" to the "Object of transformation" coding (see *Table 3.7 Final Revision Coding Tool*). This was added because one of the revision questions specifically addressed whether or not the students' needed to add any capital letters. Also, for the "Relationship to language conventions" the "Optional transformation not required by language conventions" was split in two in order to capture whether this was correctly or incorrectly carried out. If a student added the word "majical" to describe the castle in the story, then it would be coded as "Optional transformation, incorrectly carried out."

This revised coding tool was then tested with another twenty student papers. Again the researcher took notes about how the tool was working and which codes continued to be troublesome. It became apparent that some students were recreating the same errors when attempting to correct spelling. For example, one child spelled brought as "brot," she attempted to correct the spelling error in blue pen, but again spelled the word as "brot." As a result, the researcher added a "no change" code to "type of transformation." This code was only used when revising on paper because these non-changes were not captured by the computer. Finally, the researcher noticed that a large number of students were adding text to the end of their stories. She decided to add a fifth code "Location of transformation." Location could be coded as beginning, within, or end. Beginning changes occurred before the title or if there was no title before the beginning of the first sentence. Within text transformations occurred anywhere in the text except the beginning or end. End transformations occurred at the end of the text. After all of these revisions were made all of the papers were rescored.

Table 3.7
Final Revision Coding Tool

Type of transformation	
Addition	Any unit may be added.
Deletion	Any unit may be deleted.
Substitution	Most often punctuation and words will be substituted.
Rearrangement	Phrases, sentences, and paragraphs will be rearranged.
No change*	Same word or phrase written again with no change to spelling or letter case.
Level of language affected by the transformation	
Punctuation	Includes beginning, middle, and ending punctuation, and correct punctuation of abbreviations and titles.
Word	Includes proper nouns, abbreviations, etc.
Group	As few as two words should be scored as a "group."
Sentence	Must contain subject and predicate; correct punctuation unnecessary.
Text	A group of sentences.
Object of transformation	
Semantics	Lexical variations, changes of meaning
Text organization	Primarily operations of segmentation, connection, cohesion
Spelling	Both lexical and grammatical aspects

Case	Change in letter case
Relationship to language conventions	
Conventional transformation correctly carried out - CC	Required by the rules of spelling, syntax, and punctuation that no variation is accepted by authoritative references (*Oxford English Dictionary*) and is correctly carried out
Conventional transformation incorrectly carried out-CI	Required by the rules of spelling, syntax, and punctuation that no variation is accepted by authoritative references (*Oxford English Dictionary*), but is incorrectly carried out
Optional transformation not required by language conventions, carried out correctly – OC	Change not required by rules of spelling, syntax, and punctuation carried out correctly.
Optional transformation not required by language conventions, carried out incorrectly – OI	Change not required by rules of spelling, syntax, and punctuation carried out incorrectly.
Location of transformation	
Beginning	Occurs before the title of first sentence of the text
Within	Occurs within the text
End	Added to the end of the text

* Blue text were the additions or changes from original coding tool.

Ten percent of the papers were scored by a second rater. The second rater was a former elementary school teacher. She was trained to use the tool and provided with examples of each aspect of the coding system (see Appendix E: Revision Scoring Guide). The researcher and second rater reached 98.4% agreement, exceeding the initial goal of 90% interrater agreement.

In order to control for the varied length of compositions, the final scores determined through this coding scheme the total number of revisions per 100 words was then calculated for each type of revision.

Quality of Writing.

Various quality indicators have been identified to determine the quality of students' writing. Determining the quality of student writing has plagued researchers for well over 40

years (Huot, 1990). Multiple factors inhibit researchers' abilities to identify quality writing. Rubrics that examine specific features often are used to judge the quality of students' writing (Goldberg, Russell, & Cook, 2003). For a rubric to be reliable, often it has be simplified to an extent that it is no longer able to capture the rich variation of students' writing (Huot, 1990). The range of rubrics and the challenges of obtaining interrater agreement make rubrics alone insufficient to capture the diversity and complexity of students' writing. By collecting myriad quality indicators ranging from simple word count to lexical density and rubrics, this study aims to disentangle second grade students' writing and determine the quality of their products.

Narrative Rubric.

The children's task was to compose a story. To determine how well their writing accomplished this goal, a narrative rubric was be used to examine their texts. The Writing What Your Read (WWYR) narrative rubric had been proven valid and reliable for students from first grade through sixth grade (see APPEDIXES: Appendix A: Writing What Your Read Narrative Rubric from CRESST and Appendix C: Writing What You Read: Overall Effectiveness Rubric) (Gearhart, Herman, Novak, Wolf, & Abedi, 1994). Since this rubric was appropriate for sixth grade students, ceiling effects would not be an issue.

Raters have been proved to be biased due to legibility, spelling, and mechanics text (Briggs, 1970; Graham, 1999; Klein & Taub, 2005; Rezaei & Lovorn, 2010). To attempt to prevent bias, all of the texts were typed with corrected spelling and mechanics (Graham et al., 1997; Olinghouse & Graham, 2009; Purcell-Gates, Duke, & Martineau, 2007). The raters scored these corrected texts to assess the content of students' writing without penalizing them for developmentally appropriate errors or handwriting issues.

Initially, a former elementary school teacher scored all of the students' drafts and final stories using the WWYR rubric. All of the scores were examined to determine the reliability of the tool. Because some of the students made no changes or only changed spelling or punctuation that was corrected when the stories were typed for scoring 28 stories had identical stories. When examining the scores, it became apparent that the scores were not consistent. These scores should have been identical, however, they were equal less than 79% for each category: theme (61%), character (71%), setting (61%), plot (68%), communication (79%), and overall (64%). The sum score was only identical 24% of the time. It was apparent there were serious issues with the tool. The researcher and the rater began a discussion about the challenges of using this tool and began to make modifications to make it more reliable. The language in the tool was vague making it possible to easily assign the same paper different scores for the same item.

The final rubric went through nine different versions with changes ranging from modifying one level of one category to adding an entire category. The final rubric included a new category "Dialogue." One of the challenges with the communication category was the need to have dialogue to receive a score of two. However, many second graders wrote high quality texts that met a level three or four criteria for communication, but were unable to receive those scores because their stories did not include dialogue. In some cases, the story had an individual character that was overcoming a challenge and there were no other characters to talk with.

Table 3. 8.
Final Version Narrative Rubric

	1	2	3	4	5
Topic/Theme	Not present	Meaning centered in a series of list-like statements ("I like my mom. & I like my dad. & I like my…")	Coherent action itself ("He blew up the plane. Pow!"): a meaningful reaction to action	Beginning exploration of theme – emotional response	Beginning revelation of theme on both explicit & implicit levels through more subtle things characters say & do

Character	Has one or two characters	Relationship between the characters is action-driven;	Some rounding, usually in the physical description or relationship to other people, such as sister, king, etc. Description of character is mostly one word (evil, nice, magic, etc)	More detailed physical description OR beginning explanation of character feelings(know feelings, but not motivation) OR description of special characteristics (can shoot fireballs, etc) OR character changes from beg to end of story (ie from good to evil)	Beginning insights into the motivation & intention that drives the feeling & the action of main characters often through limited omniscient point of view; beginning dynamic features
Setting	Backdrop setting with little or no indication of time OR place ("There was a little girl. She liked candy.")	Any indication of time OR place often held in past time ("once there was…"); little relationship to other narrative elements	More description of setting that could be stereotypical (scary/forest).	Setting becomes more essential to the development of the story in explicit ways: characters may remark on the setting or the time & place may be integral to the plot	Setting may serve more than one function & the relationship between the functions is more implicit & symbolic – for example, setting may be linked symbolically to the character mood
Plot	One event with little or no conflict.	Two or more events	Single, linear episode with clear beginning, middle, & end; must have problem and solution	The episode contains four critical elements of problem, emotional response, action, & outcome	Plot increased in complexity with more than one episode; each episode contains problem, emotional response, action, outcome; beginning relationship between episodes; Meaningful scene change for it to be new episode
Communication	Writing bound to context (You have to be there), possibly dependent on drawing.	Beginning awareness of reader considerations; straightforward style & tone focused on getting the information out	Writer begins to make use of explanations & transitions ("because" & "so") (If the child only uses "&" for transitions it is not enough for a 3.) OR literal style centers on description ("sunny day"); tone explicit	Increased information & explanation for the reader (linking ideas as well as episodes) OR words more carefully selected to suit the narrative's purpose (particularly through increased use of detail in imagery)	Some experimentation with symbolism (particularly figurative language) which shows reader considerations on both explicit & implicit levels; style shows increasing variety (alliteration, word play, rhythm, etc.) & tone is important
Dialogue	No dialogue	Beginning dialogue, "Hi," "Bye…"	Dialogue that shows beginning emotion or moves the story along.	Dialogue contains key elements, continued action, or complex emotional expression.	Complex dialogue is interwoven with well-developed plot, theme, or setting & is crucial to the development of these elements.
Overall	A character suspended without time, place, action, or conflict. More of a statement than narrative.	Action-driven narrative written in list-like statements. Character(s) & setting minimal. Plot minimal or missing key pieces in sequence, conflict, or resolution.	One episode narrative (either brief or more extended) which includes beginning, middle, & end.	Includes four critical elements of problem, emotional response, action, & outcome. One or more of these elements may be skeletal. The characters & setting are related but often fairly stereotypical, as is the language which describes them.	More than one episode narrative with greater insight into character motivation. Beginning revelation of theme on double levels (both implicit & explicit), & setting is more essential to the tale. Language more detailed, more suited to the narrative, & offers careful transitions.

Another change found in the final rubric is "Theme" became "Topic/Theme." When reviewing the original article the authors discussed using topic instead of theme, for second grade students identifying themes became a challenge. Thinking of it as topic/theme and modifying the indicators, allowed the researcher to increase reliability and capture more second grade variation.

Throughout the rubric "OR" was added to be able to capture more variation between drafts. For example, the initial rubric stated, "Writer begins to make use of explanations and transitions ('because' and 'so'); literal style centers on description ('sunny day'); tone explicit;" the final rubric stated, "Writer begins to make use of explanations and transitions ("because" and "so") OR literal style centers on description ("sunny day") OR tone explicit." This allowed students to get credit using transitions, even if they did not provide additional descriptions. The final rubric also made a score of one lower than the initial rubric. Because these were second grade students, some failed to write a story complex enough to obtain a one on the original rubric. The highest score on the final rubric was a five rather than a six because the second graders were unable to write at the same level as a high-achieving sixth grader.

The researcher scored the all of the stories first and final drafts in a random order. Then, she put the stories together and checked to make sure the revisions the child made to their text warranted the changes in the scores. If there was a mistake in scoring, it was corrected at this time. If the researcher was unsure about one of the scores, then it was set aside to be discussed with the second rater. This resulted in 27 stories that were discussed with the second rater. The second rater also scored ten percent of the stories, first and final drafts. The goal for interrater agreement was above the minimum of 85% agreement, +/- 1, which was obtained for all of the variables except the total score, which was the sum of the seven quality indicators (see *Table 3.9*

Percent of Interrater Reliability for Quality Rubric Scores). While the total score had a variation of as high as plus or minus 3 points that is a score change of 9%, while the plus or minus 1 for the other quality categories was a change of 20%, meaning that it is still within the same range and equally reliable.

Table 3.9
Percent of Interrater Agreement for Quality Rubric Scores

	Theme	Character	Setting	Plot	Communication	Dialogue	Overall	Total
0	94	94	88	97	91	94	88	61
+/- 1	6	6	12	3	9	6	12	24
+/- 2	0	0	0	0	0	0	0	9
+/-3	0	0	0	0	0	0	0	6

All the scores have a possible total score of 5 except Total, which has a total possible score of 35.

After an examination of the data, it was determined that the all of the Plot and Overall scores were identical. As a result, the Overall score was removed from the analysis. After all of the scores were calculated for both mediums on the draft and final products, they were entered into a single database to determine the reliability of the tool. Cronbach's alpha was run on the remaining rubric items to evaluate whether or not it measured similar quality constructs. With all of the categories included in the analysis Cronbach's alpha was .630. When setting and dialogue were removed, Cronbach's alpha increased to .722, which was acceptable. For all Narrative Rubric Scores (NRS) from this point forward include the composite score of: theme, character, plot, and communication.

Table 3. 10.
Final Narrative Rubric based on Cronbach Alpha

	1	2	3	4	5
Topic/Theme	Not present	Meaning centered in a series of list-like statements ("I like my mom. & I like my dad. & I like my…")	Coherent action itself ("He blew up the plane. Pow!"): a meaningful reaction to action	Beginning exploration of theme – emotional response	Beginning revelation of theme on both explicit & implicit levels through more subtle things characters say & do
C	Has one or two	Relationship	Some rounding,	More detailed	Beginning insights

	characters	between the characters is action-driven;	usually in the physical description or relationship to other people, such as sister, king, etc. Description of character is mostly one word (evil, nice, magic, etc)	physical description OR beginning explanation of character feelings(know feelings, but not motivation) OR description of special characteristics (can shoot fireballs, etc) OR character changes from beg to end of story (ie from good to evil)	into the motivation & intention that drives the feeling & the action of main characters often through limited omniscient point of view; beginning dynamic features
Plot	One event with little or no conflict.	Two or more events	Single, linear episode with clear beginning, middle, & end; must have problem and solution	The episode contains four critical elements of problem, emotional response, action, & outcome	Plot increased in complexity with more than one episode; each episode contains problem, emotional response, action, outcome; beginning relationship between episodes; Meaningful scene change for it to be new episode
Communication	Writing bound to context (You have to be there), possibly dependent on drawing.	Beginning awareness of reader considerations; straightforward style & tone focused on getting the information out	Writer begins to make use of explanations & transitions ("because" & "so") (If the child only uses "&" for transitions it is not enough for a 3.) OR literal style centers on description ("sunny day"); tone explicit	Increased information & explanation for the reader (linking ideas as well as episodes) OR words more carefully selected to suit the narrative's purpose (particularly through increased use of detail in imagery)	Some experimentation with symbolism (particularly figurative language) which shows reader considerations on both explicit & implicit levels; style shows increasing variety (alliteration, word play, rhythm, etc.) & tone is important

Word Count.

The length of students' written compositions provides insights into their ability to write connected texts (Bangert-Drowns, 1993). It is important to note, however, that the literature on text length indicates that longer texts are not necessarily indicative of higher quality (Cochran-

Smith, 1991). As such, word count (WC) as an outcome of writing is limited in its ability to indicate the quality of a particular written artifact. Word count may, however, be used as an additional indicator of quality even though it is not as robust as other indicators.

One of the benefits of analyzing word count with digital revisions is the nature of space when revising on the computer. When children revise on paper, they are confined by space constraints. While they may want to add an additional sentence, it is challenging to fit a new sentence or even phrase in the space between lines or in the middle of a line of text. While revising on the computer, children have infinite space. Students can add text to any section and the remaining text is moved down the page. The affordances of technology make word count essential to include in any analysis examining paper and computer revision. Word count was calculated for the draft and final stories in both mediums using Microsoft Word's Word Count feature.

Lexical Density.

A more robust indicator of text quality is lexical density (LD). Lexical density is the proportion of content words in a text, which provides insights into its complexity (Williamson, 2009). Lexical words are nouns, lexical verbs (e.g. run, walk, sit), adjectives, and adverbs. Function words are not included in the analysis; these words include: determiners (e.g. the, my, those), pronouns, prepositions, conjunctions, numeral, and auxiliary verbs (e.g. can, will, have).

$$Lexical\ density = \frac{number\ of\ lexical\ words}{total\ number\ of\ words} * 100$$

The more content words the higher the lexical density and the more complex the text. To determine the lexical density of the stories, the researcher will enter the texts into the Text Content Analysis Tool (http://www.usingenglish.com/resources/text-statistics.php). This tool

provides various statistics about the texts including lexical density and word count. Lexical density was calculated for all student writing samples.

Percent of Words Spelled Correctly.

Second grade students are still learning to master the English language. Their texts are expected to have spelling errors as they are learning to write more complex sentences and stories. By counting the percent of words spelled correctly (PWSC) in their texts, the researcher can capture changes across mediums and drafts. For example, one of the affordances of technology is the spell check feature. In other studies the researcher has conducted, this has served to both help and hinder primary grade students' writing. With a first grade classroom a student had misspelled the word "cousin," when using the spell check he mistakenly selected the word "cosign." The number of spelling errors may change depending on the method of revision (paper or computer-based) and the draft (initial or final).

Spelling errors were counted once for each misspelling. If the same word was misspelled more than once, with the same spelling, then it was only counted one time. One student consistently spelled princess, as princiss, although she wrote princiss six times in her story, it was only counted as incorrect one time. Some students misspelled the same word multiple ways. For example, one girl misspelled talked three different ways: toket, tolket, and tolkt. Each new misspelling was counted. The appropriate word had to be spelled correctly in the context to count. Percent of words spelled correctly was calculated for each text. Reporting the scores in the positive rather than the negative made the higher scores more desirable and consistent with the other quality indicators where higher numbers indicated higher quality.

Relationship of Quality Indicators.

The four quality indicators measured different aspects of writing quality. The number of words measured length. Lexical density captured the proportion of content words. Percent of words spelled correctly examined spelling ability. The narrative rubric score captured the quality of content regardless of spelling and mechanics. A long text could have a low number of words spelled correctly, or a text with a high narrative rubric score could be a short text. The unique contributions of each indicator were examined prior to running advanced statistical analyses.

CHAPTER IV: ANALYSES AND RESULTS

Data analysis was carried out in three phases. First, all data were scored and interrater agreement was established (see Chapter III). Then, all data were screened for missing data, outliers were identified, and tested for normality. Finally, statistical and descriptive analyses were conducted to answer the following research questions.

1a. Is there a significant difference between the revisions second grade students make when using handwriting or a word processor?

1b. Is there a significant difference between the change in quality from the initial to final draft of second grade students' narrative texts when revising using handwriting or word processor?

2a. What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the number of revisions second graders make to their narrative texts using handwriting? Using a word processor?

2b. What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the quality of second graders narrative texts when revising using handwriting? Using a word processor?

Data Screening

Missing Data

Five students had missing data. Three students' computer stories were unable to be included in any analysis about the computer revised stories because they copied from a book or refused to participate. Two students' paper stories excluded because they refused to participate. In the following analyses, if the students fully participated in the medium, they were included in

the analysis for that medium only. Anytime the students had missing data from the data being analyzed, they were removed that data set.

Normality

Planned analyses included t-tests and linear regression. An examination of the normality of the scores was conducted. Normality was tested using the Kolmogorov-Smirnov test for each of the variables that would be used in statistical analysis. To be able to use statistics that require normally distributed data, the Kolmogorov-Smirnov had to have a $p>.20$.

Table 4.1
Tests of Normality: Kolmogorov-Smirnov Scores

	Paper			Computer		
	Statistic	df	Sig	Statistic	df	Sig
Revision Data						
Number of Revisions/100 words	0.177	72	0.00	0.079	71	.200*
Quality Data						
Word Count Draft	0.076	72	.200*	0.105	71	0.05
Word Count Final	0.091	72	.200*	0.134	71	0.00
Word Count Change Score	0.156	72	0.00	0.206	71	0.00
Lexical Density Draft	0.079	72	.200*	0.07	71	.200*
Lexical Density Final	0.069	72	.200*	0.069	71	.200*
Lexical Density Change Score	0.170	72	0.00	0.228	71	0.00
Percent of Words Spelled Correctly Draft	0.119	72	0.01	0.067	71	.200*
Percent of Words Spelled Correctly Final	0.092	72	.200*	0.15	71	0.00
Percent of Words Spelled Correctly Change Score	0.233	72	0.00	0.054	71	.200*
Narrative Rubric Score Draft	0.132	72	0.00	0.123	71	0.01
Narrative Rubric Score Final	0.202	72	0.00	0.122	71	0.01
Narrative Rubric Score Change Score	0.300	72	0.00	0.443	71	0.00
Cognitive Load Data						
Speed	0.153	74	0.00	0.255	74	0.00
Spelling Assessment Standardized Score	0.103	74	0.05	0.125	74	0.01

*Indicates normally distributed scores.

Based on the Kolmogorov-Smirnov scores, only Number of Revisions per 100 Words on Computer, Paper Word Count Final and Draft Scores, Paper and Computer Lexical Density Final

and Draft Scores, and Computer Percent of Words Spelled Correctly Change Scores were normally distributed. This was confirmed with an examination of the histograms. One example of the histograms is provided for the Number of Revisions (see *Figure 4.1.* Histograms for number of revisions per 100 words on paper and computer).

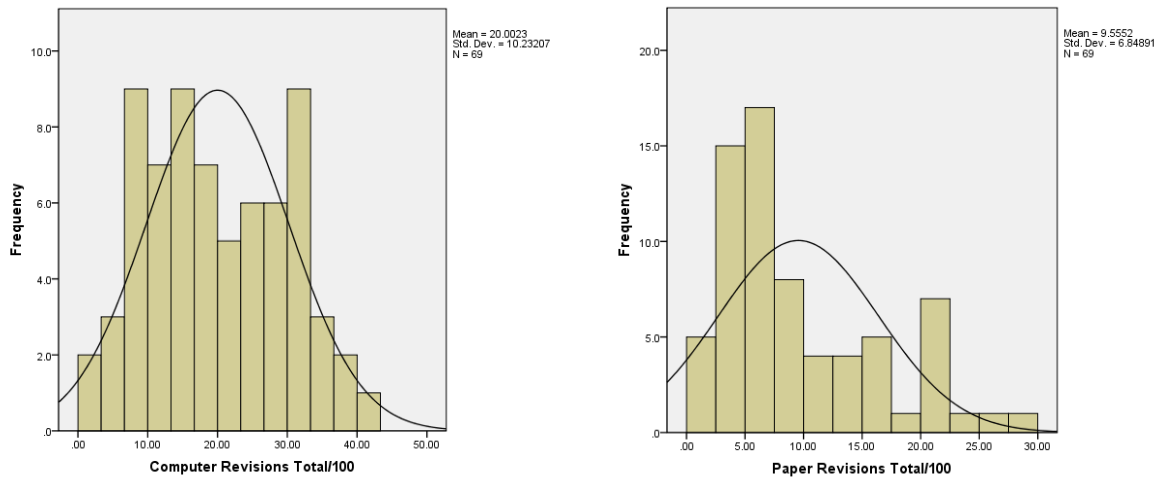

Figure 4.1. Histograms for number of revisions per 100 words on paper and computer. This figure shows the histograms for the number of revisions on paper and the computer.

Transformations were attempted to make the data normally distributed using log and inverse of the scores. However, even with the transformations the data continued to fail to be normally distributed. As a result, non-parametric tests had to be used in the majority of the analyses.

Outliers

Outliers were identified and removed from the normally distributed data set to allow for parametric statistical analysis. Outliers were determined by using z-scores for each of the variables. Any z-score with an absolute value greater than 3.29 was excluded in the analysis for that variable. A total of 3 students were outliers for at least one variable that was normally distributed. One student was an outlier for Paper Word Count Final, she wrote non-stop the entire revising session and adding on to her story making the final product much longer than her

peers. Her story went from 179 words to 374 words. However, she was a student who received special education services for writing, so she was removed from the Paper Word Count analysis only. Two students Lexical Density Scores were outliers, one on paper and one on computer. Lexical density proved to be a problematic quality indicator and will be discussed in detail in the upcoming analysis and conclusions (see Chapter V). Because of the anomalies associated with Lexical Density, these students remained in the final data set.

Final Data Set

The number of subjects included in the analysis varied because of the students, who were missing data and the one outlier. In order to keep as many students in the sample as possible, the largest number of students with complete data sets were used for the analysis. The final data set consisted of 72 students when conducting analysis of paper writing and revisions, except for Word Count, where the outlier was removed leaving 71 students. For any analysis of computer writing and revisions, 71 students were included in the final data set. Any analysis comparing paper to computer removed all students with missing data in either medium and resulted in a final data set of 69 students. All 74 students were included in any analysis of the cognitive load measures.

Correlations Among Variables

Prior to beginning analyses, all data were run to determine the correlations between variables. Spearman's rho correlations were used to determine the relationship between variables because of the large number of non-normally distributed variables. Because of the large number of variables, 36, 666 correlations were calculated. These 36 variables included the students' draft, final, and change scores for each of the quality indicators, the number of revisions, as well as the cognitive load assessments, and the scores for both the handwritten and computer versions.

When significant correlations provided further insight into planned analyses, these results are included in the discussion.

Research Question 1a

1a. Is there a significant difference between the revisions second grade students make when using handwriting or a word processor?

Question one examined the differences between revisions on paper compared to those on the computer. The study utilized a repeated measures design, students wrote two stories and revised one using paper and one using the computer. This analysis was conducted in two phases: statistical analysis and descriptive analysis.

Table 4. 2
Mean, Median, Standard Deviation, Minimum, Maximum for Paper and Computer Scores

		Paper					Computer				
Variable	N	Mean	Mdn	SD	Min	Max	Mean	Mdn	SD	Min	Max
Speed	74	74.95	66.50	27.40	28.00	153.00	33.68	32.00	23.10	8.00	166.00
WRAT Spelling	74	104.20	102.50	13.60	79.00	138.00	119.60	122.50	19.70	78.00	145.00
Revisions	69	9.56	7.14	6.85	1.16	27.91	20.00	18.52	10.20	0.81	42.20
WC*	69	31.71	20.00	36.50	-7.00	195.00	12.88	6.00	21.80	-14.00	107.00
LD*	69	-4.97	-2.67	6.92	-31.50	5.62	-2.58	-0.75	5.39	-27.60	2.73
PWSC*	69	1.93	1.28	4.01	-5.93	19.29	7.62	7.37	4.83	-7.30	17.39
NRS*	69	1.01	0.00	1.30	0.00	5.00	0.33	0.00	1.02	-3.00	5.00

Table 4. 3
Statistical Analyses for Paper versus Computer Scores

						Ranks		
Variable	N	Test	Statistic	P	R	Neg**	Pos	Tie
Speed	74	Wilcoxon	-6.893	0.000	0.801	69	5	0
WRAT Spelling	74	Wilcoxon	-6.916	0.000	0.804	6	64	4
Revisions	69	Wilcoxon	-5.755	0.000	0.692	57	12	0
WC*	69	Wilcoxon	-3.775	0.000	0.454	46	18	5
LD*	69	Wilcoxon	-2.718	0.007	0.327	24	42	3
PWSC*	69	Wilcoxon	-5.767	0.000	0.694	9	60	0
NRS*	69	Wilcoxon	-3.363	0.000	0.405	29	9	31

* The Quality Indicators are the change scores. The final score minus the draft score in each category.

** The negative ranks indicate that paper scores were higher, while the positive ranks indicate the computer scores were higher.

Table 4. 4
Mean, Median, Standard Deviation, Minimum, and Maximum for Draft and Final Scores

			Draft					Final				
	Variable	N	Mean	Mdn	SD	Min	Max	Mean	Mdn	SD	Min	Max
Paper	WC	71	80.76	76.50	41.97	16.00	217.00	110.80	108.50	51.55	18.00	258.00
	LD	72	62.59	60.48	12.87	37.00	94.40	57.39	56.97	11.75	30.50	94.40
	PWSC	72	80.90	82.58	11.94	42.86	95.83	83.13	83.86	9.67	62.50	97.37
	NRS	72	13.26	13.50	2.18	6.00	18.00	14.32	15.00	2.26	6.00	19.00
Computer	WC	71	86.13	81.00	39.47	19.00	184.00	98.83	86.00	44.54	18.00	246.00
	LD	71	61.96	62.12	11.63	38.59	94.74	59.42	58.15	10.44	37.40	94.44
	PWSC	71	82.08	82.65	10.34	56.76	97.89	89.70	91.34	8.63	61.90	99.40
	NRS	71	13.01	13.00	1.69	10.00	16.00	13.34	13.00	1.80	10.00	18.00

Table 4. 5
Statistical Analyses for Draft versus Final Scores on Paper and Computer

						Ranks				
	Variable	N	Test	Statistic	Sig.	R	Neg	Pos*	Tie	Correlation	Sig.
Paper	WC	71	T-test	-7.97	0.000	0.690	3	54	14	0.789	0.000
	LD	72	T-test	-6.248	0.000	0.595	50	10	12	0.839	0.000
	PWSC	72	Wilcoxon	-4.922	0.000	0.581	13	51	8	0.924	0.000
	NRS	72	Wilcoxon	-5.227	0.000	0.616	0	35	37	0.82	0.000
Computer	WC	71	Wilcoxon	-5.513	0.000	0.654	12	49	10	0.876	0.000
	LD	71	Wilcoxon	-3.901	0.000	0.463	46	21	4	0.889	0.000
	PWSC	71	Wilcoxon	-7.116	0.000	0.845	2	69	0	0.886	0.000
	NRS	71	Wilcoxon	-2.605	0.009	0.309	1	13	57	0.834	0.000

*Positive rank indicates the final score was higher than the draft score.

Wilcoxon Signed-Rank: Number of Revisions

The original plan was to use a paired t-test to determine if there were significant differences due to the mode of revision. Unfortunately, because the data were not normally distributed, Wilcoxon Signed-Rank tests were conducted to determine if there was a significant difference in the number of revisions (per 100 words is assumed throughout this paper) between the two mediums. While this is not as robust an analysis, it provided insights into the differences. Wilcoxon signed-rank tests compare the two scores and assign them a rank, positive, negative, or

ties. Tied scores are excluded from the analysis. After the data are ranked, the sum of the positive ranks and the sum of the negative ranks is calculated in order to determine the *z* score. There was a significant difference in the number of revisions on paper (M = 9.56, Mdn=7.14, SD = 6.85) and the number of revisions on computer (M = 20.00, Mdn=18.52, SD = 10.23); N=69, $z = -5.76$, $p < .05$, $r = .69$. 57 students made more revisions on computer, while 12 made more revisions on paper. In other words, students made significantly more changes when revising on the computer than when revising on paper. The mean scores indicate a significant change with a difference in the mean scores of 10.44 revisions, more than twice the average number of on paper.

Descriptive Analysis: Types of Revisions by Medium

Throughout the discussion of the students' revisions, the data provided are the number of revisions per 100 words unless otherwise indicated. Data were transformed to ensure that equivalent scores were being compared and students were not penalized for writing longer texts. First, a discussion of the findings from students' paper revisions is provided. Then, an analysis of their computer revisions is provided. Finally, a discussion commonalities and differences between students' revisions in the two mediums is provided.

In order to analyze the students' revisions, all of their transformations were entered into an Excel spreadsheet with each transformation receiving five codes: (1) type, (2) level, (3) object, (4) relationship to language conventions, and (5) location. Excel was then used to break down the number of revisions by code by student per 100 words. Then, it calculated the various combinations of codes by student. The spreadsheet provided data about 125 different combinations of revision codes. Each of the 125 combinations were analyzed to determine the average and median for revisions with that code combination. It was also analyzed to determine the number of students that had revisions with that combination of codes providing a percent of

students who used that code. Finally, the percent of the total number of revisions the specific code combination represented was calculated. The researcher could see the percent of revisions that occurred on the computer when students made substitutions by the object of revision: 3% semantics, 4% text organization, 59% spelling, and 18% case. She could also see the percent of students that made at least one of these revisions with this combination of substitutions on the computer by the object of revision: 28% semantics, 37% text organization, 93% spelling, and 80% case. These data were used to further explore the type of revisions students made while revising in both mediums and to dig deeper into the various trends that arose. These data are provided in the following table for the first level of codes, but data about the other combinations were reviewed by the research and included in the narrative text when applicable.

Table 4.6
Number of Revisions Per 100 Words on Paper and Computer by Type, Level, Object, Relationship, and Location

	Paper						Computer					
	Mean	Mdn	Min	Max	% Revisions	% Students	Mean	Mdn	Min	Max	% Revisions	% Students
Type												
Addition	5.00	2.96	0.00	23.26	48%	93%	2.25	1.65	0.00	14.29	11%	83%
Deletion	0.23	0.00	0.00	2.86	2%	14%	0.80	0.00	0.00	5.71	4%	44%
Substitution	4.38	3.71	0.00	17.09	42%	79%	16.74	16.24	0.00	37.83	84%	100%
Rearrangement	0.03	0.00	0.00	2.13	0%	1%	0.09	0.00	0.00	2.08	0%	7%
No Change	0.72	0.00	0.00	6.25	7%	35%	0.00	0.00	0.00	0.00	0%	0%
Level												
Punctuation	2.75	0.82	0.00	18.07	27%	54%	1.08	0.00	0.00	7.32	5%	46%
Word	4.74	3.74	0.00	23.00	46%	82%	16.96	16.24	0.80	37.84	85%	100%
Group	0.71	0.00	0.00	5.06	7%	31%	0.90	0.00	0.00	5.71	5%	41%
Sentence	0.28	0.00	0.00	5.70	3%	15%	0.19	0.00	0.00	2.00	1%	14%
Text	1.15	0.94	0.00	6.25	11%	60%	0.74	0.00	0.00	5.26	4%	44%
Object												
Semantics	3.00	1.89	0.00	16.67	29%	81%	2.24	1.96	0.00	17.14	11%	79%
Text Organization	3.18	1.16	0.00	18.60	31%	61%	2.14	1.49	0.00	15.79	11%	72%
Spelling	1.38	0.00	0.00	9.80	13%	46%	11.72	10.53	0.00	31.03	59%	93%
Case	2.05	0.76	0.00	14.29	20%	51%	3.57	2.24	0.00	24.24	18%	80%
Relationship												
Conventional Correct	4.78	3.06	0.00	19.05	46%	81%	13.28	13.59	0.00	37.78	67%	97%
Conventional Incorrect	0.57	0.00	0.00	6.00	6%	29%	3.29	1.37	0.00	19.54	17%	58%
Optional Correct	3.38	2.45	0.00	16.67	33%	82%	2.41	2.22	0.00	11.43	12%	83%
Optional Incorrect	0.90	0.00	0.00	10.94	9%	29%	0.90	0.00	0.00	5.62	5%	41%
Location												
Beginning	0.00	0.00	0.00	0.00	0%	0%	0.02	0.00	0.00	1.20	0%	1%
Within	8.28	5.64	0.00	25.58	80%	90%	18.87	18.03	0.80	40.00	95%	100%
End	1.35	1.03	0.00	6.25	13%	78%	0.98	0.89	0.00	5.26	5%	63%

Paper revisions.

On paper, the most common type of transformation was an addition. 93% of students made additions to their texts with an average of 5 (Mdn=2.96) revisions per 100 words. The most

common additions occurred at the punctuation level (M=2.45, Mdn=0.) and at the text level (M=1.04, Mdn=0), which was adding more than one sentence to the story. The second most common type of transformation was substitution with an average of 4.38 (Mdn=3.71). Substitutions most often occurred at the word level 3.80 (Mdn=2.90). The third most common type of revision was "No Change," this code indicated that the student wrote the same word, phrase, or punctuation again with no change to spelling, letter case, or punctuation. 35% of students had at least one No Change transformation with an average of .72 (Mdn=0). Deletions were only carried out by 14% students, with an average of only .23 (Mdn=0). Finally, only one student rearranged his text when he revised.

When examining the level of revision on paper, various trends arose. Students most often made revisions at the word level when revising on paper, with an average of 4.74 (Mdn=3.74). A further examination of the revisions determined that the majority of those revisions occurred when students' made changes to the letter case (M=2.05, Mdn=.76). The second most common revision when a change was made at the word level was to the spelling of a word (M=1.38, Mdn=0). The second most common level change was to punctuation (M=2.75, Mdn=.82). The object of all of these changes was text organization because by definition any change to punctuation affected the organization of the text. Revisions at the text level (M=1.15. Mdn=.94), adding more than one sentence, were the third most common with the all of those revisions affecting the semantics of the text.

The object of transformation when revising on paper was the category that had the closest averages. From largest to smallest, the mean scores were text organization (M=3.22, Mdn=1.16), semantics (M=2.96, Mdn=1.89), case (M=2.05, Mdn=.76), and spelling (M=1.38, Mdn=0). The majority of text organization changes were conventionally correct revisions (M=2.09, Mdn=0).

Other text organization changes were optional transformations that were carried out correctly (M=.58, Mdn=0) or incorrectly (M=.55, Mdn=0). The majority of the semantic changes were optional transformations carried out correctly (M=2.74, Mdn=1.84). Case changes were most often conventional correct (M=1.77, Mdn=0). Spelling transformations were most often conventionally required changes; more were carried out correctly (M=.73, Mdn=0), than incorrectly (M=.57, Mdn=0).

Students generally carried out revisions correctly on paper. 81% of students made at least one conventional revision carried out correctly, with an average of 4.78 (Mdn=3.06), correcting spelling or punctuation for example. 82% of students made optional changes that were carried out correctly with an average of 3.38 (Mdn=2.45). 29% of students made optional changes that were carried out incorrectly, with an average of .90 (Mdn=0). Of the students who made optional incorrect revisions, all but one made between one and four optional incorrect revisions. One girl made 14 optional incorrect revisions. She focused on adding punctuation to her story, and 14 of her 15 punctuation additions were incorrect. The least common revision relationship was conventional incorrect, carried out by 29% of students with an average of .9 (Mdn=0).

None of the students added on to the beginning of their stories when revising on paper. Students made an average of 8.28 (Mdn=5.64) revisions within the body of the text and an average of 1.35 (Mdn=1.03) revisions to the end. It is important to keep in mind that students could not make more than one revision to the end of the text, so the 1.35 average is somewhat misleading. More importantly, 90% of students' made revisions within the body of their stories and 78% made revisions by adding on to the end of their stories.

Computer Revisions.

The number of revisions by type varied greatly. 100% of the students made at least one substitution when revising on the computer, with an average of 16.74 (Mdn=16.24). The bulk of these substitutions took place at the word level, with an average of 16 (Mdn=14.75), and 11.7 (Mdn=10.53) of those were spelling changes or 3.57 (Mdn=2.24) were case changes. The next highest type of revision was addition, with 83% of students adding to their texts, but the average number of additions per 100 words was only 2.25(Mdn=1.65), almost 7.5 times lower than substitutions. Additions occurred at the punctuation (M=.73, Mdn=0), text (M=.68, Mdn=0), word (M=.45, Mdn=0), group (M=.3, Mdn=0), and sentence (M=.1, Mdn=0) levels. 44% of students made deletions, with an average of .8 (Mdn=0), most of these students deleted a single word (M=.51, Mdn=0). Only 5 students (7%) attempted rearrangements.

When revising on the computer, the majority of the changes occurred at the word level (M=16.96, Mdn=16.24). 100% of the students made revisions at the word level. All of the other level changes were a more than 15.5 times lower. The next highest average level was punctuation at 1.08 (Mdn=0) revisions per 100 words. Only 46% of students made punctuation changes (M=1.08, Mdn=0), 44% made changes at the text level (M=.74, Mdn=0), 41% made changes at the group level (M=.9, Mdn=0), and a mere 14% made changes at the sentence level (M=.19, Mdn=0). The computer encouraged students to attempt word level changes at a much higher rate than any other level. As described in the last paragraph, this resulted in a large number of spelling (M=11.72, Mdn=10.53) and case (M=3.57, Mdn=2.24) changes.

The object of transformation was most often spelling (M=11.72, Mdn=10.53) with 93% of students making spelling changes when revising on the computer. Of these spelling changes, 8.48 (Mdn=8.45) were conventionally carried out correctly and 3.07 (Mdn=1.02) were

conventionally carried out incorrectly. While the computer was unable to help students correct the spelling of all of the words they attempted fix, it was able to help them improve the spelling of the majority of them. Changes to case (M=3.57, Mdn=2.24) were the second most frequent object of revisions, with most of these revisions conventionally carried out correctly (M=3.06, Mdn=1.96). Students continued to make semantics (M=2.24, Mdn=1.96) and text organization (M=2.14, Mdn=1.49) revisions on the computer.

Students generally carried out revisions correctly on the computer. 97% of students made at least one conventional revision carried out correctly, with an average of 13.28 (Mdn=13.59). Many students also made optional changes that were carried out correctly, 83% with an average of 2.41 (Mdn=2.22). Interestingly, the average number of conventional revisions that were incorrect (M=3.29, Mdn=1.37) was higher than the optional correct (M=2.41, Mdn=2.22); however, these changes were carried out by a smaller percentage of students 58%. The high number of these conventional incorrect revisions was caused by the large number of incorrect spelling attempts with an average 3.07 (Mdn=1.02) of the 3.29 (Mdn=1.37) total conventional incorrect revisions. Case changes were the next highest conventional incorrect change at .14 (Mdn=0). Optional incorrect revisions were carried out by 41% of the students with a mean of .90 (Mdn=0).

The location of the changes continued to primarily be within the text (M=18.87, Mdn=18.03). All of the students made revisions within the text, while 63% of students added on to the end of their stories. One student added a title to his story and therefore added to the beginning of the text.

Comparison of Revisions in Both Mediums.

When revising on the computer, revision patterns shifted. First of all, the average number of revisions per 100 words increased significantly from 9.56 to 20, an increase of 10.44. On paper the number of revisions ranged from 1.16 to 27.91, while on computer the range was .81 to 42.22. This finding indicates that the computer facilitated students' revision processes.

The medium of revision greatly impacted the types of revisions students made to their stories. This was most apparent in the substitution means. On paper substitutions averaged 4.38 (Mdn=3.71), but on computer these increased to 16.74 (Mdn=16.24), an increase of more than 12 revisions per 100 words. On the computer all of the students made substitutions, while only 79% of students made them when revising on paper. Substitutions accounted for only 42% of revisions on paper, while they were 84% of all revisions on the computer. The most common type of revision on paper was addition (M = 5, Mdn=2.96)) accounting for 48% of all revisions, while this was the second most common revision on the computer it only accounted for 11% of all revisions (M = 2.25, Mdn=1.65).

The highest level of revision in both mediums occurred at the word level. On paper the number of revisions at the word level had a mean of 4.74 (Mdn=3.74) and on computer it rose to 16.96 (Mdn=16.24). Despite being the highest level in both mediums, the percentage of revisions these scores accounted for vary greatly. On computer 85% of the revisions occurred at the word level, while only 46% of the revisions on paper.

An even greater difference occurs when examining the object of revision. On computer the bulk of these word level revisions were spelling changes with a mean of 11.72 (Mdn=10.53), with only 1.38 (Mdn=0) on paper. Spelling changes accounted for 59% of revisions on the computer, but only 13% of the changes on paper. This indicates that the availability of spell

check facilitates students' revisions. Spell check underlined misspelled words and made spelling errors apparent to students, encouraging them to attempt corrections. On paper text organization (M=3.18, Mdn=1.16) changes were the most common and accounted for 31% of all revisions, this was followed closely by semantics (M=3, Mdn=1.89) with 29% of revisions. When revising on computer, these accounted for far fewer revisions. Text organization (M=2.14, Mdn=2.14) and semantics (M=2.24, Mdn=1.96) were each 11 % of all revisions.

For the relationship to language conventions, the highest mean and percent of revisions in both mediums was conventionally correct. When revising on paper, 46% of the revisions were conventionally correct (M=4.78, Mdn=3.06), and on computer it was 67% (M=13.28, Mdn=13.59). However, students made more optional correct revisions on paper accounting for 33% of revisions (M=3.38, Mdn=2.45), than when revising on the computer with 12% of all revisions (M=2.41, Mdn=2.22).

Another interesting trend consistent across both mediums was the large number of students who added on to the end of their stories: 78% of students when revising on paper and 63% on computer. This indicates that a major understanding of second grade students that part of revising a story is adding on. None of the revision questions specifically addresses adding on to the end of the story. Question two was "Can I add any details or juicy words?" Also, neither of the revising examples provided included adding on to the end of the story. One possibility is the short period of writing time during the first day of writing was not enough time for them to finish their stories. Another possibility is once the students finished revising the stories with the Writers' Questions, they thought they were supposed to write the entire period and so added on.

Research Question 1b

1b. Is there a significant difference between the change in quality from the initial to final draft of second grade students' narrative texts when revising using handwriting or word processor?

Quality was measured using four variables: Word Count (WC), Lexical Density (LD), Percent of Words Spelled Correctly (PWSP), and Narrative Rubric Score (NRS) (see Chapter Three for a full description of each variable). Having four variables measuring the same construct could lead to an inflation of Type I error, to combat this a Bonferroni Correction was used. An intial *p* value of .05 was divided by four. For all analyses of quality, the new *p* value was .0125.

To answer question One A, multiple analysis were conducted. First, to determine if the revisions affected the quality of the final product, the draft and final scores were compared in each medium. Then, the change scores, which were calculated by subtracting the final score from the draft score, were compared for paper and the computer.

Analysis of Word Count

A paired-samples t-test was conducted to compare the final word count to the draft word count when students revised using paper. There was a significant difference in the word count on the draft (M = 80.76, Mdn=76.50, SD = 41.97) and final story (M = 110.76, Mdn=108.50, SD = 51.548); t(70) = -7.97, $p < .0125$, $r = .69$. 54 students wrote more words for their final story than their draft, 3 wrote fewer words for their final story, and 14 students' word count score did not change. The average score increased by 30 words. This finding indicates that when revising using paper students increase their word count.

Because the Computer Word Count scores were not normally distributed, Wilcoxon signed-rank tests were used to compare the final word count to the draft word count when

revising on the computer. There was a significant change in the draft word count (M = 86.13, Mdn=81.00, SD = 39.47) and final word count when revising on computer (M = 98.83, Mdn=86.00, SD = 44.54); N=71, z = - 5.51, p < .0125, r = .65. 49 students increased their word count after revising on computer, 12 decreased their word count, and 10 had no change in word count. The average score increased by 12.7 words. Revising on the computer also increased students' final word count.

Since students increased their word count in both mediums, a Wilcoxon signed-rank test was conducted to determine, if there was a significant difference in the word count change scores when revising on paper and on the computer. There was a significant difference the change in scores on word count from the draft to the final score on paper (M = 30.71, Mdn=20.00, SD = 36.50) and when revising on computer (M = 12.88, Mdn=6, SD = 21.80); N=69, z = - 3.78, p < .0125, r = .45. 46 added more words when revising their stories on paper, only 18 students added more words to their computer story, and 5 changed the same number of words in both mediums. Students increased their word count by an average of 17.85 more when revising on paper, than when revising on the computer. This finding indicates that when students revise using paper they increase their stories by more words than when revising on the computer.

Analysis of Lexical Density

A paired-samples t-test was conducted to compare the draft lexical density (LD) to the final LD when students revised using paper. There was a significant difference in the LD on the the draft (M = 62.59, Mdn=60.48, SD = 12.87) and final story (M = 57.39, Mdn=56.97, SD = 11.75); t(71) = - 6.25, p < .0125, r = .60. The average LD score decreased by 5.2 from draft to final story. LD was intended to capture students using more complex language and more unique words in their texts. 50 students LD scores decreased from draft to final, 10 increased, and 12

had no change in LD score. As students revised their texts using paper, their LD scores decreased. Spearman's rho bivariate correlations were run on the LD scores and the other quality indicators. Significant relationships occurred between the LD draft and final and the WC draft and final, ranging from r=-.666 to -.789, p (two-tailed) <.05. This indicates that there was a negative relationship between the LD scores and the WC scores.

The computer LD scores were not normally distributed, so a Wilcoxon signed-rank test was used to determine if there was a difference between the draft and final LD scores. There was a significant change in the LD draft score revising on computer (M = 61.96, Mdn=62.12, SD = 11.63) and on the final story when (M = 59.42, Mdn=58.42, SD = 10.44); N=71, z = - 3.90, p < .0125, r = .46. 46 students decreased their LD after revising on computer, 21 increased their LD, and 4 had no change in LD. The mean LD score decreased by 2.54 when revising on the computer. LD scores decreased when students revised using the computer.

In both mediums, LD scores significantly *decreased* as a result of revision. The LD change scores were not normally distributed, so a Wilcoxon signed-rank test was used to determine if there was a significant difference in the change scores for LD between revision mediums. There was a significant difference the change in LD score from the draft to the final score on paper (M = -4.97, Mdn=-2.67, SD = 6.92) and when revising on computer (M = -2.58, Mdn=-.75, SD = 5.39); N=69 z = - 2.72, p < .0125, r = .38. LD scores decreased in both mediums. 42 students decreased their lexical density scores more on paper than on the computer, 24 had greater decreases in lexical density scores on computer, and 3 had no change between mediums. LD scores decreased an average of 2.40 more when revising on paper than when revising on the computer. As students revised their texts, their LD scores decreased more on paper than on the computer.

Analysis of Percent of Words Spelled Correctly

Wilcoxon signed-rank tests were used to analyze the Percent of Words Spelled Correctly (PWSC) variables because they were not normally distributed. When revising on paper, there was a statistically significant difference in PWSC on the draft (M = 80.90, Mdn=82.58, SD = 11.94) and on the final story (M = 83.13, Mdn=83.86, SD = 9.67); N=72, z = -4.92, p < .00, r = .92. 51 students had more words spelled correctly in their final story than on their draft, only 18 students spelling was worse on their final story, and 8 students had no change in their scores. While this may be a statistically significant finding, the difference in the mean scores was only 2.23%. Spelling scores did not greatly improve when revising on paper.

There was a significant change in the PWSC on the story draft when revising on computer (M = 82.08, Mdn=82.65, SD = 10.34) and final story (M = 89.70, Mdn=91.34, SD = 8.63); N=71, z = -7.12, $p < .00$, $r = .89$. 69 students improved after revising on computer, 2 decreased their PWSC. A large number of students were able to improve their spelling when revising on the computer by an average of 7.62%.

When comparing students PWSC change scores on paper and computer, there was a significant difference in the paper PWSC change score when revising on paper (M = 1.93, Mdn=1.28, SD = 4.01) and when revising on computer (M = 7.62, Mdn=7.37, SD = 4.83); N=69, z = -5.77, $p < .00$, $r = .70$. While spelling scores increased in both mediums, computer scores increased an average of 5.69% more than when revising on paper. 60 students made had a larger change in the number of words spelled correctly on computer, while only 9 made more on paper. The medium of revision accounted for 48% of the variance in PWSC change score.

Analysis of Narrative Rubric Scores

The students Narrative Rubric Scores (NRS) were not normally distributed, as a result Wilcoxon signed-rank tests were used to analyze the data. There was a significant difference in NRS draft scores (M = 13.26, Mdn=13.50, SD = 2.18) and final scores when revising on paper (M = 14.32, Mdn=15.00, SD = 2.26); N=71, z = - 5.23, p < .0125, r = .62. 35 students improved their rubric score after revising on paper, while 37 made no change in their rubric score. While NRS scores increased an average of 1.06 points, the large number of students who made no change to their scores indicates that revising on paper alone does not necessarily improve the NRS scores.

When revising on the computer, there was a significant difference in the NRS draft (M = 13.01, Mdn=13.00 SD = 1.69) and final scores (M = 13.34, Mdn=13.00, SD = 1.80); N=71, z = - 2.61, p < .05, r = .309. 13 students increased the final NRS after revising on computer, 1 decreased the NRS, and 57 had no change. While this finding is statistically significant because of the large number of students who made no changes, this is misleading. Overall despite the significant finding, students failed to improve their final rubric scores after revising on the computer.

Comparing the revision medium on the change score for NRS, there was a significant difference on paper (M = 1.01, Mdn=0, SD = 1.30) and computer (M = .33, Mdn=0, SD = 1.02); N=69, z = - 3.36, p < .0125, r = .41. While fewer students improved their NRS from draft to final story, 27 students made more improvements to their paper stories, only 9 students made more improvements to their computer stories, and 31 students made equivalent changes or no changes to their paper and computer stories. These findings indicate that the students are most likely to make equivalent or no changes that affect the NRS score on either paper or computer, if

they do make revisions that affect the quality they are more likely to make them when revising on paper.

Research Question 2a and 2b

2a. *What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the number of revisions second graders make to their narrative texts using handwriting? Using a word processor?*

2b. *What patterns exist between the cognitive load of transcription measured by writing speed and spelling ability and the quality of second graders narrative texts when revising using handwriting? Using a word processor?*

Initially, linear regression was going to be used to analyze the effects of the cognitive load of transcription on the number of revisions and the quality of their writing. However, since such a large number of variables were not normally distributed, even when transformations were attempted, Wilcoxon signed-rank tests and a descriptive analysis were conducted to answer the second research questions. First, Wilcoxon signed-rank tests were used to determine if there were significant differences in the cognitive load of transcription on paper versus the computer. The cognitive load was measured with writing or typing speed and the standardized scores from the WRAT4 spelling assessment. Then, a descriptive analysis was conducted to examine the impact on students' revisions and quality.

Cognitive Load Measures Analysis

To measure the cognitive load of transcription, writing speed was measured by having students write or type a sentence with all of the letters of the alphabet as many times as possible in a two minute period. The score was calculated by counting the number of correct letters written during that time. Wilcoxon signed rank test was used to determine if there were

differences in the number of letters written in both mediums. There was a significant difference in the speed scores on handwriting on paper (M = 74.95, Mdn=66.50, SD = 27.43) and typing on the computer (M = 33.68, Mdn=32.00, SD = 23.11); N=74, z = - 6.89, p < .05, r = .80. 69 students were able to handwrite faster than they could type, while only 5 students typed faster than they could handwrite. One student wrote a staggering 96 more letters when typing than handwriting. Two of the students wrote 4 more letters on the computer and the other two students wrote 31 and 17 more letters. Students wrote an average of 41.27 letters more when handwriting. This indicates that the cognitive load of transcription, with regard to writing speed, was higher when typing.

To measure the cognitive load of transcription with regards to spelling, the WRAT4 spelling assessment was used. The standardized scores were used, with an average score based on the test manual of 100 and standard deviation of 15. A Wilcoxon signed rank test was used to determine that there was a significant difference in the standardized assessment spelling scores when handwriting (M = 104.20, Mdn=102.50, SD = 13.60) and typing on the computer (M = 119.60, Mdn=122.50, SD = 19.70); N=74, z = - 6.92, p < .00, r = .80. 64 students improved their spelling scores on the computer, while 6 had higher scores when handwriting, and 4 received the same scores in both mediums. Students' scores improved an average of 15.41, which is one standard deviation based on the WRAT4 scoring guidelines. This finding indicates that the cognitive load of spelling is significantly decreased when typing on the computer. The researcher observed all students using the spell check while administering the spelling assessment. Indicating, the spell check was a tool that supported students' spelling. The use of spell check was also specifically taught and reviewed during the training sessions.

These separate aspects of the cognitive load of transcription, speed and spelling, had differing effects on students' transcription abilities. While the computer supported students spelling on a standardized test, it hindered them with regards to writing speed. These findings were further confirmed with the findings from students' revision practices in the two mediums. Computers were not used in these classrooms to write and the three computer training sessions were not enough to teach typing skills, but provided a foundation to be able to successfully use the spell check.

Effects of Cognitive Load on Revisions: Descriptive Analysis

From the Wilcoxon signed-rank tests, on the computer the cognitive load of transcription increases when typing with regards to writing speed, but decreases when spelling as a result of the spell check feature. These conflicting findings highlight the transcription challenges of using technology in the classroom and the effects of the cognitive load of transcription on students' revisions. As previously discussed, students made significantly more revisions on the computer (M=20.00, Mdn=18.52), than on paper (M=9.56, Mdn=7.14). In spite of the increased effort required for writing speed, with students writing an average of 41.27 more letters on paper, students made more changes on the computer.

On the computer, the object of revision was most often spelling (M=11.72, Mdn=10.53) and accounted for 59% of the revisions. Not only did a large percentage of students attempt to correct spelling, they were successful 73% of the time. On paper only 13% of the revisions were spelling changes (M=1.38, Mdn=0). However, they were only successful 56% of their attempts. These results are consistent with the significantly higher spelling scores on the computer spelling assessment. The spell check and underlined misspelled words encouraged students to attempt to correct more spelling words when revising on the computer than on paper.

Effects of Cognitive Load on Quality: Descriptive Analysis

When examining the impact of the cognitive load of transcription on the quality of students' revised stories, the effects become even more apparent. Word count and percent of words spelled correctly demonstrate the importance of the cognitive load of writing and how it affects students' revisions.

There were significant differences in the word count change score with regards to the revision medium. On paper the change score on word count was a mean of 31.71 (Mdn=20.00), while on the computer the mean was 12.88 (Mdn=6.00). This confirms the difference in the cognitive load writing speed measures between the mediums. On paper students wrote an average of 74.95 (Mdn=66.50) letters in a two minute period, while on the computer it was only 33.68 (Mdn=32.00), less than half the number of letters written on paper. The challenges of typing on the computer hindered students' abilities to increase the length of their stories.

The differences in spelling scores also confirmed the cognitive load measure findings. The change score for the percent of words spelled correctly on paper was only an average improvement of 2.23%, while on the computer scores increased an average of 7.62%. Again, this confirmed scores on the WRAT spelling assessment, computer scores were over one standard deviation higher than paper scores (based on the tool standard deviation); computer scores were an average of 5.69% higher than paper scores. This was further supported by the Spearman's rho correlations between the WRAT handwritten and computer scores and the students' draft and final PWSC when handwriting and spelling. The relationships varied between r=.592 to .774, p (two-tailed) <.05. This indicates that the standardized assessments were able to capture some of the variance associated with students' spelling ability in a revision task. Spell check supported

students spelling when revising on the computer and significantly improved their spelling on their final stories.

Summary of Analyses

The research question 1a examined the differences in the revisions when students used paper versus the computer.

- Students made significantly more revisions on the computer than on paper.
- When revising on paper, the most common type of revision was an addition; the most common level of revision was at the word level; the most common object of revision was text organization, but all of these were close; and the majority of their revisions were conventional revisions that were carried out correctly.
- When revising on the computer, the most common type of revision was substitution; the most common level of revision was at the word level; the most common object of revision was spelling; and the majority of their revisions were conventional revisions that were carried out correctly.
- The greatest difference between mediums occurred with the higher number of substitutions on the computer compared to paper.

Research question 1b examined the effect of medium on the quality of students writing. Analyses indicate:

- Students increased their word count from draft to final in both mediums, with students adding more words to the stories revised on paper than on computer.
- Lexical density decreased from draft to final story when revising in both mediums. These scores decreased more on paper than on the computer.

- Students improved the percent of words spelled correctly when revising in both mediums. These score improved more when revising on computer than when revising on paper.
- While narrative rubric scores may have statistically significantly increased when revising in both mediums, the large number of students, who had no change in scores, made this finding misleading. Technically, students made more improvements when revising on the paper than on the computer.

Research question 2a examined the impact of the cognitive load on transcription on students' revisions. Analyses indicate:

- The cognitive load of writing speed is greater on the computer, while the cognitive load of spelling is greater on paper. These findings indicate that aspects of the computer can be beneficial, but can also hinder students' written work.
- In spite of the greater cognitive load of writing speed on the computer, students still made more revisions on paper than on the computer.
- Spelling was the most common object of revision when using the computer, and they were generally able to correct spelling errors. On paper, students attempted to correct fewer spelling errors.

Research question 2b examined the effects of the cognitive load of transcription on students' quality. Analyses indicate:

- As a result of the increased cognitive load of writing speed on the computer, students revised stories word counts increased more on paper than on the computer.
- As a result of the decreased cognitive load of spelling on the computer, students revised stories corrected more spelling errors on the computer than on paper.

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CHAPTER V: DISCUSSION

Primary grade students are learning to master the complexities of writing, from lower-level skills such as transcription to higher-level skills such as planning and revision (Flower & Hayes, 1981; Hayes, 1996; Hayes, 2012). The cognitive load of transcription, measured by writing speed and spelling ability, drains resources, making it challenging for young writers to attend to higher-level writing skills, such as planning and revision (McCutchen, 2006). The Common Core State Standards (CCSS) call for primary grade students to learn to revise texts. Revision encompasses a wide range of skills from low-level text editing to high-level reconceptualization of text (Butterfield et. al., 1996). These skills include: deciding to change the focus of a text before beginning to write, identifying and correcting a mismatch between the written text and the intended message, correcting the spelling of a misspelled word, and many others (Fitzgerald & Markham, 1987). Transformations are the physical evidence of the revisions that occur either on paper or on the computer between drafts. Prior research has provided evidence that second graders are capable of revising texts (Dix, 2006; Fletcher, 2000; Nuvoli, 2000). Dix (2006) found that elementary writers are capable of revising texts with purpose and an understanding of the process. Other studies have provided evidence that writing speed and spelling can affect the overall quality of students' written work (Berninger et al., 1997; Graham & Harris, 2000; McCutchen, 2006; Negro & Chanquoy, 2005). The new emphasis on writing brought about with the introduction of the CCSS combined with the existent literature base's minimal research on primary grade students' revisions makes this area crucial for exploration. This study sought to fill a gap in the existing literature by examining the relationship of the cognitive load measures of writing speed and spelling ability on the capacity of second grade students to revise texts and the effect these revisions have on the overall quality of their texts.

The first factor examined by this dissertation is primary grade students' abilities to revise texts. Related to this is the second major element of this study, the impact of technology on students' revisions. This aspect is important because of the prevalence of technology throughout society and the CCSS assessments use of computers to assess students' writing quality. The CCSS writing standard for second graders calls for students to "use a variety of digital tools to produce and publish writing" (Council of Chief State School Officers & National Governors Association, 2014). In the most recent nationwide survey of primary grade teachers, 42% of teachers reported they never use computers for writing and 25% use them only a few times a year (Cutler & Graham, 2008). This is troubling because computers are used exclusively by the two biggest test makers to assess students' writing starting in third grade (PARCC, 2014; SBAC, 2014). If states are going to use digital assessments and expect students to perform at a high-level, then understanding the impact of technology on writing in the primary grades is essential for lawmakers, educators, parents, and researchers. Few studies have examined the effect of computers on primary grade students' writing (e.g. Jones, 1994; Jones & Pellegrini, 1996; Shaw, et al, 1994; VanLeeuwen & Gabriel, 2007) and even fewer examined students' revisions on the computer (Fletcher, 2001; Nuvoli, 2000). Nuvoli (2000) found that elementary writers could use the computer to revise texts in ways that increased the number of words and corrected a significant number of errors. This study adds new information to the limited literature base on primary students' use of computers for writing by exploring the relationship between second grade students' revisions on paper and the computer.

This chapter will provide a discussion of the research questions and connect these findings to prior research. Then, the chapter explores the implications for educators,

administrators, and researchers. Finally, an explanation of the limitations of the current study and directions for future research will be provided.

Research Question 1a

Research question 1a examined the differences between the revisions second graders make when using paper and pencil and those made when using a word processor The only studies identified in the existing pool of research that compared digital and paper revisions focused on middle school students. These studies yielded mixed results, with one study finding that revising on the computer increased revision (Grejda & Hannafin, 1992) and another study finding no difference in the number of revisions (Joram et al., 1992). There have been few studies that have explored early elementary grade students' revisions on paper or on the computer (Dix, 2006; Fletcher, 2000; Nuvoli, 2000), however no studies were identified that compared handwritten to computer revisions with this age group.

Findings from the current study indicate that second grade students made twice as many revisions on the computer than when revising on paper. This dissertation aligns with the findings of Grejda and Hannafin (1992) demonstrating that increased revision on the computer may emerge as early as second grade. Dauite (1983) suggested that students hesitate to make revisions to handwritten texts because of the messy look of insertions and cross outs. Primary grade students who reported to prefer writing on the computer cited their reasons as: the ease of deletions and insertions, the neater look and ease of reading, and their hands did not get tired (Seawel et al., 1994). The use of technology, which makes texts look professional and revisions invisible to the reader, could have encouraged students to make more revisions, but was not directly examined in this dissertation.

Perhaps more important than the number of revisions made is the purpose and function of the revisions. The current study coded each revision in five ways: (1) *type*, (2) *level*, (3) *object*, (4) *relationship*, (5) *location*. The coding category for *type* was based on Allal (2000) and aligned with the findings of Dix (2006). Revision types include addition, deletion, substitution, rearrangements and restructuring. Dix conducted a small study with eight to ten year old students examining student revisions on paper, and found that the type of revisions children primarily made were additions, deletions, and substitutions as opposed to rearrangements. The current study was consistent with Dix's findings. Across both mediums, students in the current study primarily made low-level transformations: additions, deletions, and substitutions. However, the most common type of revision shifted when working on paper versus working on the computer. On paper, the most common revisions were additions (48%). When revising on the computer the most prevalent form of revision was substitution, making up 84%. Further, similar to Dix (2006), the current study found that rearrangements and restructuring were the least common types of revisions made, regardless of the medium. In fact, only one student rearranged the text on paper and only five made rearrangements on the computer. Rearrangements and restructuring are higher-level revisions, perhaps requiring more practice and instruction. When these skills develop is currently unknown, as the current findings are also consistent with research involving upper elementary and middle school students (Allal, 2000; Chanquoy, 2001; Crawford et al., 2008), indicating that these higher level revisions may not be a skill acquired potentially until high school.

The second revision code examined the *level* of revision: (a) punctuation, (b) word, (c) group, (d) sentence, or (e) text. In the current study, significant differences appeared between paper and computer revisions, especially with regards to word level revisions. While word level

revisions were the most common in both mediums, the frequency of revisions varied greatly. On paper, 46% of revisions occurred at the word level while on the computer (85%) almost twice as many word level revisions occurred.

By examining the findings from the third revision code, the cause of this difference becomes readily apparent: the increase in the number of spelling changes, which all occur at the word level. Only one study identified provided detailed information about the *level* of students' revisions. In a case study with four sixth graders revising on paper, Allal (2000) found that three of the four students made at least 20% of their revisions at the word level, specifically changing spelling. Only one of the students made changes at the word level that affected another *object* of transformation, specifically text organization. Together these findings indicate that the medium and the age of the students may affect the *level* of students' revisions. Further research could illuminate the differences between medium and participate age.

The third revision code examined the *object* of transformation: (a) semantics, (b) text organization, (c) spelling, and (d) case. The most interesting finding from this code is the differences between the numbers of spelling transformations in both mediums. In the current study, students made significantly more spelling changes on the computer (59% of all revisions) than on paper (13%). One possible cause for the increase in the number of spelling revisions on the computer is the presence of the red indicator line to focus students' attention to misspelled words. On the computer, students had access to spell check with the word processor provided bank of words to help them correct misspellings. The end result was students were able to correctly revise 72% of the words they attempted to spell on the computer while on paper students only corrected the spelling of 55% of the words attempted. This highlights one of the key affordances of technology for young writers and supports the findings of Nuvoli (2000).

Nuvoli found that second to fifth graders were successfully able to use computers to revise stories and improve spelling on the computer. The availability of spell check may encourage students to attempt to correct more misspellings and can enable them to correct more misspelled words than when writing on paper.

The fourth revision code used in this study captured the *relationship of revisions to writing conventions*. Transformations were coded as conventionally required changes, which were necessary to correct an error in the text, these could be either carried out correctly or incorrectly; or optional changes, which could also be carried out correctly or incorrectly. In the current study, the most common transformations were conventionally required changes carried out correctly 46% of the time on paper and 67% of the time on computer. Students made more optional changes on paper (42%) than on the computer (17%). These findings indicate that students are able to make revisions that can improve the conventional quality (i.e. correcting the spelling of a misspelled word, inserting a missing punctuation mark, or deleting a double word) of their writing. By examining the *relationship of revisions to writing conventions*, this study sought to understand why revisions often do not improve the overall quality of the text (Bereiter & Scardamalia, 1987; Cochran-Smith, 1991; Fitzgerald & Markham, 1987), is it because the revisions do not improve the quality at the micro-level or the micro-level revisions are not enough to improve the overall quality. As there is little research on young writers, studies with older students are being utilized. Crawford, Lloyd, and Knoth (2008) conducted a study about fifth and eighth graders revisions. Individual revisions were evaluated as increasing the quality, decreasing the quality, or neutral. They found that 60% of revisions increased the quality, 20% decreased, and 20% of revisions were neutral. Allal (2000) conducted a small study with 4 sixth grade girls. They found that the high-achieving girls carried out more optional transformations

and when they made conventionally required changes, they were usually carried out correctly. The middle-achieving girls carried out fewer optional transformations and while they still had more conventionally required changes that were correct, a higher percentage of conventional changes were carried out incorrectly. The findings from this dissertation and the previous studies seem to indicate that students are capable of making revisions that improve the conventional quality at the micro-level, but are less apt to make optional changes at any level.

The final code examined the *location* of transformation, meaning where in their text they made changes (e.g., beginning, middle or end). While conducting the review of literature, little prior research captured the location of the transformations students made. This study adds a distinctive understanding of students' revisions that is unavailable in many studies. The need for this code became apparent as the researcher examined students' revisions and a large number of students added on to the end of their stories. The majority of students added on to the end of their texts. 78% of students added on to the end of their document when revising on paper and 63% when revising on the computer. In the early developmental revision studies, researchers found that much of the primary grade students' revisions were focused on "making stories grow" (Calkins, 1981, 1983; Graves, 1983). Instead of revisiting the previously written text, students add on to their stories making them bigger without examining the initial text. This highlights an understanding these second graders may have about the revision processes. Like the early revision research, students in this study may have a belief that revision meant adding to the story by making it longer.

Research Question 1b

Research question 1b examined the differences between the change in *quality* from the initial to final draft of students' narrative texts when revising using pencil and paper and a word

processor. This question is essential because the ultimate goal of revision is to improve the text - if the revisions do not improve the texts, then why take time away from other literacy activities. Any study that examines revision that fails to measure overall text quality fails to capture the purpose of revision. Interestingly, researchers have found that the process of revising a text does not necessarily lead to a higher quality final product (Bereiter & Scardamalia, 1987; Cochran-Smith, 1991; Fitzgerald & Markham, 1987). Definitions of quality can encompass a vast array of indicators, from low-level word count to higher-level narrative rubric scores. The current study utilized four quality indicators to capture the change in quality (a) *word count*, (b) *lexical density*, (c) *percent of words spelled correctly*, and (d) *narrative rubric score*.

Word Count

The lowest level indicator used in this study was *word count*. Word count was an important indicator because it is widely used in research with primary grade students' writing (e.g. Barrera et al., 2001; Chanquoy, 2001; Glaser & Brunstein, 2007; Jones, 1994; Jones & Pellegrini, 1996; Olinghous, 2008; Olinghous & Leaird, 2009) and provides an easy method to capture quality change. In prior research, *word count* increased from first to final draft as a result of revision in studies including second graders revising on the computer (Fletcher, 2001; Nuvoli, 2000) and word count increased across mediums with sixth graders (Grejda & Hannafin, 1992). Results of the present study indicate that word count increased in both mediums, but students added significantly more words when revising on paper than on the computer. In fact, students added more than twice the number of words when revising on paper than on the computer. Interestingly, in their study comparing computer revisions to paper revisions with sixth graders, Grejda and Hannafin (1992) found that the group revising on the computer added more words and sentences than the group revising on paper. One possible reason for this difference is that

older students could be more familiar with computers and revision, which could allow them to increase text length more in that medium than on paper. Second graders are still learning how to type, as evidenced in the current study by their higher handwriting speeds and slower typing speeds, which will be discussed further later in the chapter (see *Research Questions 2a and 2b*). Their limited knowledge of typing may have impaired the second grade students' ability to increase word count on the computer.

Lexical Density

While *word count* provides an indication of change, it does not necessarily speak to the quality of the change, which is why it was only one of the four quality indicators used in this study. *Lexical density* measures the total number of content words compared to the total number of words in the text. It has successfully been used in previous research with primary grade students as an indicator of writing quality. *Lexical density* was selected as an indicator because of the work of Jones (1998) and Jones and Pellegrini (1996). In both studies with primary grade students, kindergarten and first grade respectively, the researchers found that *lexical density* increased with text quality and in the case of Jones (1998) with the use of computer-generated spoken feedback. Neither of these studies compared first to final drafts of individual children, but instead compared students to each other. In the study with first graders comparing computer to paper compositions, Jones and Pellegrini (1996) found that *lexical density* scores were higher on computer than on paper. However, the researchers do not provide *word count* scores, so it is possible that the *word count* was lower on the computer, falsely indicating higher quality.

In the current study, *lexical density* was a problematic indicator. The initial hypothesis was that the higher the *lexical density*, the higher quality the text. But, the opposite finding was

revealed. As students' stories became longer, (i.e., increased word count scores), their *lexical density* scores significantly decreased on paper and the computer.

When reviewing students' scores in this study, it became readily apparent that students with longer stories had much lower *lexical density* scores than students with shorter stories. The lowest *lexical density* score was on paper 30.48; her *lexical density* score dropped 8.07, while her word count increased from 179 to 374. The highest *lexical density* score was on the computer 94.44, and the student wrote a total of 18 words for his final draft and had 19 words in the initial draft, decreasing his *lexical density* score by .3. When revising, he made three spelling changes and combined a word, which decreased the word count by one.

To further examine why this results may have occurred, *lexical density* was re-examined in order the control for the varying length of different essays. To do this the lowest *word count* score identified in the current data (16) as the "base" for each essay. However, after examining a number of students with longer stories, it was determined that their *lexical density* scores varied depending upon which 16 words were selected to score. While selecting the first 16 words may be "fair," it may also not actually capture the true nature of the students' writing. Because of this, *lexical density* was determined to be a problematic indicator, and while included in the analysis it was not viewed as a reliable quality indicator for this study. The efficacy of *lexical density* may also be questionable for use in other research until an appropriate method for controlling word count is developed and tested.

Percent of Words Spelled Correctly

The *percent of words spelled correctly* is a third important quality measure because it captures a typical editing skill, can be supported by spell check, and its use is widespread throughout the literature (e.g. Olinghous, 2008; Olinghous & Graham, 2009; Walter & Connelly,

2010). For this study, its inclusion was essential because one of the key affordances of a word processor is the availability of spell check and the appearance of a red indicator line when a word is misspelled cueing a students' attention. This study found that the *percent of words spelled correctly* significantly increased in both mediums from first to final draft. Prior research supports this finding (Nuvoli, 2000) and on paper (Dix, 2006). Moreover, when revising on the computer students spelling ability outperformed their ability to accurately spell when using pencil and paper. This result seems to indicate that second graders benefit from the advantages of computerize spelling supports such as spell check. Again, this finding is consistent with that found in the prior literature examining the performance of older students writing via computer (Grejda & Hannafin, 1992; Walter & Connelly, 2010).

Narrative Rubric Score

Improving the overall narrative rubric quality score proved to be more challenging to quantify than other quality indicators. While some students in the present study were able to improve the quality of their narrative in both mediums, over half failed to increase their narrative rubric scores on paper (52%), and 82% did not improve their scores when revising on the computer. Although the current study had "statistically significant" differences between mediums and when comparing the first to final drafts in both mediums, this finding is highly questionable and reveals a major study limitation. The narrative rubric scores were not normally distributed, as a result, Wilcoxon Signed-Rank tests were run. The Wilcoxon Signed-Rank test compares two scores and removes any ties (no change from one time to the next) from the analysis, thus providing information only about the students who had changes in their scores. With the low number of students who had score changes for narrative rubric, these results are suspect. The low numbers of the students in this study that increased their narrative rubric scores

is consistent with previous research findings conducted with more mature students that revision does not necessarily improve the overall quality of the text (Bereiter & Scardamalia, 1987; Cochran-Smith, 1991; Fitzgerald & Markham, 1987; Grejda & Hannafin, 1992; Joram et al., 1992). Researchers have hypothesized learning to revise in ways that improve overall quality may take additional time to develop (Grejda and Hannafin, 1992). They also questioned if word processing may inadvertently encourage students to focus on micro-level changes rather than using a holistic approach that could improve the overall quality. Calkins (1983) found that many third graders "refined" texts, fixing spelling or surface errors, without affecting the voice or framework of the draft. These types of refinements would not be enough to change a narrative rubric score, but could improve the mechanics of the text. It appears that many students in the current study were focused on refining their texts, making it difficult for them to improve their narrative rubric scores.

In addition to these reasons for the lack of clear improvement from the previous work, there may be additional issues that attenuated narrative score results stemming from the design of the current study. First, the lack of movements in the scores may be related to the instructions that helped students focus on the task of revision. When reflecting on the "Writers' Questions" (see Figure 3.1. Writers' questions) provided to scaffold revision activity, only three of the questions would encourage students to improve the overall narrative quality: (1) Does it make sense? How can I fix it?; (2) Can I add any details or juicy words?; (3) Can my reader form a clear picture?. While these are similar to questions primary grade students were taught to use while revising in other research: Does it make sense?; Have I provided enough information?; and Is this how I can write it accurately? (Dix, 2002 as cited in Dix, 2006), perhaps the students continue to view the purpose of revision as editing. Additional revision prompts and cueing

systems have been used in prior research to encourage revision and students continued to focus on surface changes (Graham, Harris, McArthur, & Schwartz, 1991). Additional research is need to determine what types of revision prompts or questions could be used to encourage more holistic revisions that could lead to greater changes in the narrative quality.

Perhaps a second reason contributing to the lack of movement in the quality narrative scores may be related to the limited exposure students had to using the computer as a medium through which to write and revise text. The familiarity with the medium became apparent with a greater number of students improving their Narrative Rubric Scores on paper, than on the computer. The revisions on paper provided evidence that some students as young as second grade may be able to use revision to improve the narrative quality of their stories, but the statistics analyses were not robust. Learning to improve the overall quality of the narrative texts appears to require additional practice and instruction, as evidenced by research with Self-Regulation, Strategy Development (SRSD), which teaches students to plan and revise their writing; these studies have shown significant improvement of elementary students' writing quality (Graham, McKeown, Kiuhara, & Harris, 2012). Improving narrative quality is more challenging than lower-level quality indicators, but it may be possible with appropriate instruction and support.

Research Questions 2a and 2b

Cognitive load theory posits that learners can be overloaded with low-level tasks leaving few resources free for higher-level undertakings (Hayes & Berninger, 2010; Sweller, Ayres, & Kalyuga, 2011). With inexperienced writers, writing speed and spelling ability interferes with transcription (Berninger & Swanson, 1994; Graham & Harris, 2000; Hayes & Berninger, 2010; McCutchen, 1996, 2000, 2006), leaving limited Working Memory (WM) resources available for

setting goals, idea generation, and revision (Hayes & Berninger, 2010). Chanquoy (2001) called upon researchers to explore experimental paradigms that decrease the cognitive load to free up WM resources for revision. This study seeks to help answer that call. One of the unique aspects of the dissertation is the examination of the cognitive load of writing, with regards to writing speed and spelling ability, on second grade students' revisions and the quality of their stories. The following discussion focuses on questions 2 and 2a examining the impact of the cognitive load of transcription on revisions and the quality of the final narrative texts, endeavoring to help to fill a significant gap in the literature.

Cognitive Load of Transcription

The cognitive load assessments used in this study provided insights into how the method of transcription could affect the revisions and quality of students' work. The second grade students were able to handwrite more than twice as fast as they could type, which was consistent with the significantly higher handwriting speeds across elementary grades found in previous research (Connelly, Gee, and Walsh, 2007; Hayes & Berninger, 2010). Standardized spelling scores on the Wide Range Achievement Test (WRAT) were significantly higher on the computer than on paper, indicating that second grade students may be capable of taking advantage of the spelling supports available when word processing. During the administration of the assessment, the researcher observed students checking the spelling of words highlighted by the red indicator line and checking the spelling word bank for the appropriate word. Computers served as both a support and a hindrance for students in this study. When writing on the computer the cognitive load of writing speed appears to increase, while the cognitive load of spelling appears to decrease because of the support from spell check.

Effect of Cognitive Load on Revisions

The extant literature highlights the negative impact of transcription skills on students' writing through fourth grade (Berninger & Swanson, 1994; Graham & Harris, 2000; Hayes & Berninger, 2010; McCutchen, 1996, 2000, 2006). Researchers have theorized that transcription ability limits WM resources for planning, idea generation, and revision (Hayes & Berninger, 2010). This study provides data about the effects of the cogntive load of transcription in two mediums on the revisions students make to narrative texts. In spite of the increased cognitive load of writing speed, students made more than twice as many revisions on the computer than on paper. This indicates that the affordances of the technology appear to have outweighed the slower typing speeds and encouraged students to make more revisions. This apparent contradiction becomes clear when an examination of the types of revisions is conducted. As previously stated, the cognitive load of spelling decreased on the computer. On paper, the most common objects of revision were text organization and semantics, together accounting for 60% of all revisions. When revising on the computer, spelling alone accounted for 59% of all revisions. The availability of spell check and the red indicator line seems to have encouraged students to attempt more spelling revisions. Not only did students attempt more revisions, these revisions were more often correct with 72% of attempted spelling changes correct on the computer compared 55% correct when spelling was revised on paper.

Effect of Cognitive Load on Quality Scores

Researchers have explicitly linked the quality of texts to the WM constraints of transcription ability for young writers (Berninger & Swanson, 1994; Graham & Harris, 2000; Hayes & Berninger, 2010; McCutchen, 1996, 2000, 2006). In the current study, cognitive load factors affected the quality scores. The significantly lower cognitive load of writing speed when

handwriting led to significantly higher word count change scores when revising on paper; the higher cognitive load for typing speed led to lower word count change scores when revising on the computer. This aligns with previous research with elementary writers where handwriting speed directly affects word count scores (Graham et al, 1997). In an examination of eighth and ninth grade students handwritten and computer composed texts, researchers found a significant relationship between the writing speed in each medium and the word count scores (Christensen, 2004). Interestingly, while the writing speed measures predicted the word count scores in both mediums, the computer word count scores were much higher than the handwritten word count scores. This may indicate a developmental shift as students become older, their typed texts become longer than handwritten texts. These findings seem to indicate that the cognitive load of transcription, particularly writing speed, may impact students' word counts from elementary school through early high school.

Spelling ability as measured by a standardized assessment on paper predicted students' spelling when typing on the computer when spell check was available with upper elementary students (Walter & Connelly, 2010). No studies were identified that assessed students' spelling ability (i.e. WRAT4) on the computer and on paper making the current study unique. This adds a new dimension to the literature base and allows for direct comparison between spelling ability and percent of words spelled correctly in a composition between two mediums. With the availability of the spelling tools on a word processor, being able to differentiate the affordances of the tool from students' handwritten spelling ability provides new insights. In the current study, students' standardized spelling assessment scores on the computer were significantly higher than when handwriting indicating that the cognitive load of spelling decreased on the computer with access to the spelling features. This pattern was apparent in the scores for percent of words

spelled correctly. Students corrected significantly more words when revising on the computer than when revising on paper. Together these findings demonstrate the potential benefits of spell check for elementary writers. The availability of the red indicator line with the available word bank appears to support elementary students' attempts to correct spelling errors and could potentially serve to enhance their ability to correctly revise their texts.

Research has demonstrated that quality is directly related to students' transcription abilities (Berninger & Swanson, 1994; Graham & Harris, 2000; Hayes & Berninger, 2010; McCutchen, 1996, 2000, 2006). While less than half of the students in either medium improved their narrative rubric scores, paper scores were statistically significantly higher, than on the computer. This finding may indicate that the familiarity with the medium, as demonstrated by the lower cognitive load of handwriting speed, may affect the overall quality of the text. Interestingly, in research with upper elementary students, Walter and Connelly (2010) found that typing speed predicted the quality of students' typed texts, faster typists had higher quality typed texts. The current study was unable to directly compare an individual's typing speed to his or her quality scores because of the lack of normally distributed data. The small percentage of students who improved their narrative rubric scores when revising on the computer (18%) indicates that the lack of experience with typing and experience writing on the computer may have impeded the students' ability to revise stories in ways that negatively affected the overall narrative quality.

Implications

The findings from this study have implications for classroom teachers, administrators, and researchers alike. Primarily, second graders appear to be capable of revising texts on paper and on the computer with appropriate instruction and training. Understanding the intersection between technology and writing in the primary grades has become more important than ever with

the digital assessments developed for the Common Core State Standards. Therefore, classroom teachers need to have the support, whether it be planning time or computer training, and computers necessary to provide students with opportunities to compose texts on the computer as well as on paper. By providing students with more experience using the computer to compose texts, they will be better prepared for the CCSS assessments and their lives in the real world.

Second graders are capable of revising texts.

Second graders seem to be capable of revising texts as evidenced by this dissertation and the findings of other researchers (Dix, 2006; Fletcher, 2000; Nuvoli, 2000). First, revision does not need to be thought of as a high-level skill that should only be introduced as students become more mature writers. With appropriate instruction, second graders in this study were able to make additions, substitutions, and deletions both on paper and on the computer. Rearrangements appear to be higher-level revisions that require additional practice and instruction as evidenced by this study and the work of Dix (2006). Second, the findings of this dissertation and prior research are important because the CCSS call for students to begin revising and editing in second grade and understanding how students' revise can serve to improve instruction, as well as guide future research. Third, exposure to revision in the primary grades can serve as a way to authentically teach students about the writing process. Finally, teachers may need to be provided with training in how to teach revision as well as tools to support students' revisions. The teachers in this study had received extensive training in the process approach to writing and, as a result, their students were able to revise texts in meaningful ways.

Second graders can use spell check.

Spell check can be beneficial for students' writing on the computer. The cognitive load of spelling, measured with WRAT4, demonstrated that second graders, with appropriate instruction

on how to use the computer, may significantly improve spelling scores on standardized assessments. Even more important than scores on a standardized assessment, students' percent of words spelled correctly may increase when revising narrative texts on the computer. The red indicator line appears to serve as a reminder to writers that a spelling error has been detected and encourages students to attempt to correct spelling mistakes using the bank of words provided by the word processing program. On paper there are no visual supports to highlight spelling errors. Other studies about specific computer programs have also found that primary grade students seem to be able to successfully take advantage of computer tools, including spell check, to improve writing (Englert et al., 2004; Holdich et al., 2004). The CCSS call for second graders to use digital tools to compose texts. This dissertation provides further evidence that the affordances of technology may serve to improve students' writing. The challenge for educators is in gaining access to computers and having the support necessary for students to use them for writing. Teachers may need training on how to teach students to take advantages of the affordances of the computer for composition. Computers should serve as tools to support revisions, specifically spelling, and provide students practice using one of the writing mediums called for by the CCSS. While computers may encourage students to focus on spelling changes while revising, as evidenced by the high number of spelling revisions on the computer, they should be used for writing in the primary grades because of the new CCSS digital assessments and the nature of the digital world, which these students inhabit. The nature of writing and assessment is changing and the shift to digital writing means that even our youngest writers need experience using spell check and the other supports provided by digital writing environments.

Differences between modes of revision.

Second grade students seem to be more likely to make revisions that improve the quality of writing on paper than on the computer, which may be due to their limited training in computer use. In the current study, students' word count scores were significantly higher on paper than on the computer and their overall narrative rubric quality scores were also higher on paper. This implies that familiarity with the medium matters. With the cognitive load of transcription speed higher when typing than when handwriting, the effects are apparent in the quality scores. More than two and a half times the number of students were able to improve the narrative rubric quality scores on paper versus the computer in the current study. In order to allow students to take advantage of the affordances of technology and have the opportunity to increase typing speeds, students appear to need typing training and the opportunity to experience composing texts, as well as revising them, on computers. A few training sessions are not enough to allow second graders to improve writing quality on the computer, with the exception of words spelled correctly.

Cognitive load theory highlights the importance of working memory on complex cognitive tasks (Hayes & Berninger, 2010; Sweller, et al., 2011). Typing can easily overload working memory leaving few resources available to improve writing quality. Second graders, who have not learned to touch type, tie up cogntive resources searching for a specific letter or remembering how to make an exclamation point, which takes away from their ability to focus on meaningful ways to revise their texts. With the higher cogntive load of typing, CCSS assessments and other digital writing tasks should possibly provide students with extended time to compose texts because of elementary students' slower typing speeds. Without an extended period for typing, the assessments may fail to capture students' writing ability. By providing

students with typing lessons teachers can decrease the cogntive load of typing and possibly allow students to take full advantage of the affordances of digital composition. Typing instruction should be a key component of elementary students' curriculum, the majority of their writing as they grow older shifts to digital composition and beginning earlier prepares them for the CCSS assessments and the widespread use of technology throughout their lives.

Lexical density as a problematic quality indicator.

Lexical density has provided insights into quality in previous research (Jones, 1998; Jones & Pellegrini, 1996); however, in this dissertation, it was negatively correlated with other quality indicators. This contradiction indicates that lexical density may not be useful for assessing quality in all research. For example, if the lowest word count across mediums in this dissertation was greater than 50 words then all of the texts could be scored for lexical density for 50 words. This could provide insights into the complexity of students' writing. However, with such a small lowest word count score, assessing the first 16 words did not accurately capture the complexity of students' texts, students may have a more or less lexically dense introduction than other parts of the text. Researchers should use caution when selecting lexical density as a quality indicator. In the research of Jones (1998) and Jones and Pellegrini (1996), they did not compare first to final drafts. It is possible that they were not capturing quality in the way intended. Word count greatly affects lexical density scores and, unless word count is controlled for, lexical density scores may mask students' writing quality.

Improving overall narrative quality with revision is challenging.

The findings of this dissertation and other researchers have found that students are capable of making revisions that improve the conventional quality of students' stories, such as correcting the spelling of a misspelled word or adding a missing punctuation mark (e.g. Allal,

2000; Crawford et al., 2008). The majority of students' revisions across grade-levels tend to make surface changes (Chanquoy, 2001; Crawford et al., 2006; Dix, 2006; Flower et al., 1986; McCutchen, 2006) or consists of "refining" texts (Calkins, 1981, 1983). These types of changes and low-level editing revisions do not necessarily improve the overall narrative quality. In order to make revisions that significantly affect narrative quality scores, students would likely need additional instruction (Cochran-Smith, 1991; Dix, 2006; Fitzgerald & Markham, 1987). Teacher should have receive training, if needed, to support their students in making more substantive revisions that could lead to higher quality overall texts, moving revision beyond an editing task.

Limitations and Directions for Future Research

This study's quantitative and qualitative analyses can potentially provide significant contributions to the field of literacy research. The results are bounded by the limitations of the design and methodology and, therefore, provide valuable insights into directions for future research. Various issues with sampling, research design, and statistical power emerged throughout data collection and analysis.

Measurement Issues

Narrative Rubric Measurement.

The narrative rubric score captured little variation from first to final draft. After revising, only 48% of students' scores changed on paper and 18% changed on the computer. One possibility is that increasing narrative rubric scores is significantly more difficult than increasing word count or the percent of words spelled correctly. Another possibility is that changing one word, such as "big" to "enormous," is not enough to affect the overall quality of a text. Another possibility is that the final tool, while able to capture some variability, is unable to capture the wide range of skills second graders exhibit, while continuing to be reliable and valid.

An additional issue with the narrative rubric scores is that setting and dialogue had to be removed from the final analysis because of low Cronbach's alpha scores, $\alpha = .630$, indicating that they measured different constructs than the other rubric items. Dialogue, which was included as part of communication in the original version of the rubric, was an interesting measure because the scores varied greatly and some students wrote stories that did not require dialogue. For example, one story was about a boy going on a run and making it all the way to five miles. The boy in the story built up his running, going one mile, then two, then three, etc. There was building action, high-level descriptions, and a conclusion, but no need to include dialogue because there were no other characters. Setting was also dropped from the final narrative rubric score because of the low Cronbach's alpha score. Setting is often discussed and highlighted in second grade classrooms. Having to drop setting from the analysis made it a less authentic measure of what second graders are taught in classrooms.

In order to make a tool that had high interrater agreement and accurately measured quality scores, some of the items were made less complex and more distinct from higher and lower scores. These changes could have simplified the tool to an extent that it failed to capture some variation in students' texts. Narrative quality scoring tools are a challenge to create and refine.

Sampling Issues

The dissertation was constrained by the resources available to the researcher. Future research will benefit from expanding on the following sampling issues:

Participants.

The current sample included only 74 second grade students in a middle-class suburban school district in a Midwestern metropolitan area. The generalizability of this study is limited to

students in similar settings, and should not be applied to older students, high-risk populations, or other demographically different students. Future studies should include a wider range of ages to determine if there are differences among different grades or if there is a developmental pattern across grades. Another limitation of the current sample is the district's focus on writing and the extensive professional development, including that with Lucy Calkin's writing methods, being given to teachers. While these findings could be applied to a school that uses a similar writing workshop approach, it is not applicable to classrooms that do not teach revision. Also, these students had never been asked to write digital texts at school. An interesting future study could compare the results of these students to another demographically similar school with extensive computer training, including typing. Finally, the sample size is small (N=74) limiting the statistical power available to analyze their texts and revisions.

Lack of statistical power.

A major weakness of the current study is the lack of statistical power. The only normally distributed variables were paper word count and lexical density scores. All of the other variables suffered from various issues affecting normality, such as ceiling effects (standardized spelling scores) or too many scores clustered together with few scores at either end of the continuum (narrative rubric scores). As a result, the majority of the analyses used non-parametric Wilcoxon Signed-Rank tests, which is not as robust a tool as the more common parametric t-test. The lack of normally distributed data also made it impossible to run the planned linear regression analyses using the cognitive load variables as predictors for the number of revisions and the quality indicators. Instead, this dissertation relied on using a qualitative methodology to explore issues of cognitive load on these variables. Future studies would benefit from larger sample sizes as

well as a wider grade range. Both of these changes would increase the likelihood of having normally distributed data.

Use of one time writing tasks.

This study used one time on demand writing tasks to gather information about students' revisions. This does not mirror what happens in many classrooms, nor does it provide insights into the the consistency of students' revisions over time. These snapshots provide a glimpse into the students' complex revision processes, but fail to capture the stability of students' revision performance across tasks or the developmental continuum of revision. Future research would benefit from extended data collection across grade levels with more ecologically valid methodologies. This would provide a fuller picture of how stable students' revision patterns are over time. It could also provide support for creating a developmental continuum of revision skills.

Design issues with the initial draft.

The first issue is that the initial draft of all student texts, whether they were to be revised on paper or on the computer, were handwritten. This was done in order to control for the quality, length, and style of the initial draft. This design was especially important because of the students' lack of experience with typing texts. Because of the significantly higher cognitive load of typing, the initial drafts on the computer would likely have had shorter word counts and possibly lower initial narrative rubric scores. This study provides insights into the potential power of revising in both mediums; however, the study design limits the ecological validity of the current study. In real classrooms, teachers are unlikely to have time to type students' texts, preserving spelling and punctuation, and then have them revise using the computer. A more realistic design would have students compose their initial stories in the same medium in which

they would later revise. Students' revisions could be captured as they typed the initial draft and then when they revised their stories. Future research should use more ecologically valid designs, such as allowing students to revise texts originally composed on the computer, and compare the findings to the current dissertation.

The second issue was the limited amount of time students had to write their initial draft – only 25 minutes. This was determined, by the classroom teachers and researcher, to be a long enough time period for them to get their ideas down. This amount of time was purposely selected to ensure that students would have a draft of text to revise while still being limited enough to minimize the chance of students making massive changes to their texts at this first sitting. The students in these classrooms often composed texts over multiple days as part of larger units of writing instruction. The shift from extended writing time to a one-time on demand writing task could have affected their texts. This limitation became apparent in the large number of students, who added on to the end of their texts (78% of students on paper and 63% on the computer), significantly increasing word count. This finding makes it unclear if the students believe that revision means making a text longer, or if they did not have enough time to finish their first drafts during the initial writing period. Future research could examine the impact of revision using initial writing periods of varied lengths, 15, 25, or 35 minutes. This would allow researchers to determine if students added on to their texts because that is a belief they hold about revision or because their initial texts were unfinished due to time constraints.

Amount of instruction required to increase narrative rubric scores.

Previous research on revision has provided evidence that revisions do not necessarily lead to higher quality texts (Bereiter & Scardamalia, 1987; Cochran-Smith, 1991; Fitzgerald & Markham, 1987). This study also found that improving narrative rubric scores (48% improved

when revising on paper and 18% improved when revising on the computer) was more challenging than increasing other quality indicators. This study indicates that revision can improve narrative rubric scores, which is promising. Future research could build on this study by examining the amount and types of instruction necessary to increase narrative rubric scores through revision.

Amount of typing training.

The cognitive load of transcription, measured by typing and handwriting speed, found in this study was consistent with previous research with typing being significantly more challenging than handwriting (Connelly, Gee, & Walsh, 2007). Future research should explore the impact that typing training has on revision outcomes. Researchers could manipulate the number of hours students spend receiving typing training. Ideally, a group of students could receive enough training to be able to have typing speeds faster than their handwriting speeds. If students were faster at typing than handwriting, how would that affect the number and types of revisions students make? On the computer, students made a high number of spelling revisions. Future research could benefit from determining if this pattern continued with more experience typing and composing on the computer. The mode of the initial draft could have influenced the number of spelling revisions that occurred while revising on the computer. Research could examine if composing the initial draft on the computer decreased the number of spelling revisions on the second day, possibly freeing up cognitive resources for other types of revisions. Also, beyond typing training, future research should include classrooms that also have experience with regularly composing texts on computers. Theoretically, students with high levels of typing expertise and experience composing texts on computers would free up cognitive resources that would then be available for making more meaningful revisions to their texts.

Concluding Thoughts

This study supports the use of computers as *one* tool students in the primary grades can use to revise texts. This is especially important with the new Common Core State Standards assessments use of technology to assess student learning, which requires the use of word processors for writing samples. An extended period of time for writing should be considered for these assessments because of the higher cognitive load of typing on students' compositions. Teachers should provide students with a variety of methods to compose texts, from traditional paper and pencil to computers. Teachers may need the technological support and professional development about writing processes in order to successfully implement these instructional practices. Young writers are capable of making revisions that affect the quality of their final text and by challenging them to write at a high-level we are preparing them for an ever-changing digital future.

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APPENDIXES

Appendix A: Computer and Mobile Device Access and Use Survey

Name Teacher

1. Do you have a computer at home? □ Yes □ No
2. How often do you use the computer?
    a. Daily
    b. A few times a week
    c. Weekly
    d. Monthly
    e. Rarely
3. What do you do on the computer?
    □ Play games
    □ Visit websites
    □ Email
    □ Chat
    □ Write stories
    □ Take pictures
4. Do you have a mobile device you are allowed to use? Cell phone, IPad, Kindle, Nook, Tabeo, Leappad
    □ Yes □ No
5. How often do you use the mobile device?
    a. Daily
    b. A few times a week
    c. Weekly
    d. Monthly
    e. Rarely
6. What do you do on the computer?
    □ Play games
    □ Visit websites
    □ Email
    □ Chat
    □ Write stories
    □ Take pictures

Appendix B: Writing What You Read Narrative Rubric from CRESST

	Theme	Character	Setting	Plot	Communication
1	Not present or not developed through other narrative elements	One or two flat, static characters with little relationship between characters; either objective (action speaks for itself) or first person (author as "I") point of view	Backdrop setting with little or no indication of time and place ("There was a little girl. She liked candy.")	One or two events with little or no conflict ("Once there was a cat. The cat liked milk.")	Writing bound to context (You have to be there) and often dependent on drawing and talk to clarify the meaning; minimal style and tone
2	Meaning centered in a series of list-like statements ("I like my mom. And I like my dad. And I like my…") or in the coherence of the action itself ("He blew up the plane. Pow!")	Some rounding, usually in the physical description; relationship between the characters is action-driven; objective point of view is common	Skeletal indication of time and place often held in past time ("once there was…"); little relationship to other narrative elements	Beginning sequence of events, but occasional out-of-sync occurrences; events without problem, problem without resolution, or little emotional response	Beginning awareness of reader considerations; straightforward style and tone focused on getting the information out; first attempts at dialogue begin
3	Beginning statement of theme – often explicit and didactic ("The wicked witch chased the children and she shouldn't have done that."); occasionally the theme, though well stated, does not fit the story	Continued rounding in physical description, particularly stereotypical features ("wart on the end of her nose"); beginning rounding in feeling, often through straight forward vocabulary ("She was mad, glad, sad.")	Beginning relationship between setting and other narrative elements (futuristic setting to accommodate aliens and spaceships); beginning symbolic functions of setting (often stereotypical images – forest as scary place)	Single, linear episode with clear beginning, middle, and end; the episode contains four critical elements of problem, emotional response, action, and outcome	Writer begins to make use of explanations and transitions ("because" and "so"); literal style centers on description ("sunny day"); tone explicit
4	Beginning revelation of theme on both explicit and implicit levels through more subtle things characters say and do ("He put his arm around the dog and held him close. 'You're my best pal,' he whispered.)	Beginning insights into the motivation and intention that drives the feeling and the action of main characters often through limited omniscient point of view; beginning dynamic features (of change and growth)	Setting becomes more essential to the development of the story in explicit ways: characters may remark on the setting or the time and place may be integral to the plot	Plot increased in complexity with more than one episode; each episode contains problem, emotional response, action, outcome; beginning relationship between episodes	Increased information and explanation for the reader (linking ideas as well as episodes); words more carefully selected to suit the narrative's purpose (particularly through increased use of detail in imagery)
5	Beginning use of secondary themes, often tied to overarching them, but sometimes tangential; one theme increasingly revealed through discovery, though explicit thematic elements still predominate	Further rounding (in feeling and motivation); dynamic features appear in the central characters and in the relationships between characters; move to omniscient point of view (getting into the minds of the characters)	Setting may serve more than one function and the relationship between the functions is more implicit and symbolic – for example, setting may be linked symbolically to the character mood ("She hid in the grass, clutching the sharp, dry spikes, waiting."	Stronger relationship between episodes (with the resolution in one leading to a problem in the next); beginning manipulation of the sequence through foreshadowing, and subplots	Some experimentation with symbolism (particularly figurative language) which shows reader considerations on both explicit and implicit levels; style shows increasing variety (alliteration, word play, rhythm, etc.) and tone is important
6	Overarching theme multi-layered and complex; secondary themes integrally related to primary them or themes; both explicit and implicit revelations of theme work in harmony ("'You can't do that to my sister,' Lou cried, moving to shield Tasha with his body."	Round, dynamic major characters through rich description of affect, intention, and motivation; grown occurs as a result of complex interactions between characters; most of the characters contribute to the development of the narrative; purposeful choice of point of view	Setting fully integrated with the characters, action and theme of the story; role of setting is multifunctional – setting mood, revealing character and conflict, serving as metaphor	Overarching problem and resolution supported by multiple episodes; rich variety of techniques (building suspense, foreshadowing, flashbacks, denouement) to manipulate sequence	Careful crafting of choices in story structure as well as vocabulary demonstrate considerable orchestration of all the available resources; judicious experimentation with variety of stylistic forms which are often symbolic in nature and illuminate the other narrative elements

Appendix C: Writing What You Read: Overall Effectiveness Rubric

How are the features integrated in to this narrative?

Score	Example
1. A character suspended without time, place, action, or conflict. More a statement than a narrative.	There was a little girl who liked rainbows. Poor little Cyclops. He had one eye.
2. Action-driven narrative written in list-like statements. Character(s) and setting minimal. Plot minimal or missing key pieces in sequence, conflict, or resolution.	Sleeping Beauty has a prince. She had a balloon and a kite. The sun was very beautiful and shining. She went to a party and she had fun. She had a party dress on and her prince. Once there was a little girl. And she was 10 years old. And she was very beautiful. A big bear came out of the forest and she ran deep in the forest. Her name is Amelia. But he was going for Amelia. The little girl was very scared. But then she was happy.
3.One episode narrative (either brief or more extended) which includes the four critical elements of problem, emotional response, action, and outcome. One or more of these elements may be skeletal. The characters and setting are related but often fairly stereotypical, as is the language which describes them.	A fable would fit here. One there was a little girl. Her name was Ashley. She was very pretty. She had red hair and freckles. She also had beautiful brown eyes like brown lakes. Anyway...she was a princess that lived in a golden castle. Her father was the king of the land. Oh! I forgot! Ashley had a big sister that was not mean. Her name was Lindsey. And she was just as beautiful as Ashley, but she had brown hair. Now the real problem was the grandma. She did not like the children. She thought they were spoiled brats. But the children loved their grandmother. It so happened that the grandmother had made a plan so the next day the children would die. And this is how it turns out. Well, you see, this woman was not the ordinary grandmother. She actually was a witch. Anyway, she decided to have them go and take a walk in the forest. Then she put a pretty flower out in the path. She knew they would notice it. (If you touched the flower and then touched your hair without washing your hair before two day's time you would die!) The next day the girls took a walk in the forest and everything was going as the witch had planned except a couple of drops of water landed in the place where the flower had touched the children's hair. When the children came home, the grandma was so angry to see them alive that she jumped off a cliff and was never seen again.
4. More than one episode narrative with greater insight into character motivation. Beginning revelation of theme on double levels (both implicit and explicit), and setting is more essential to the tale. Language more detailed, more suited to the narrative, and offers careful transitions.	The True Story of Cinderella — Dedicated to all the badly treated, beautiful maidens of the world. And the beautiful Fairy godmothers that help them. Once upon a time, long ago and far away, there lived Cinderella, and her two ugly step-sisters and one step-mother. They lived in Hollywood in the biggest castle ever made and ofall people. Cinderella was the poor little servant. One night Cinderella had more work than usual. She had to sew dresses and put make-up on her two step-sisters and her ugly mean step-mother. They were going to the prince's ball. The prince was to find a wife. When her step-sisters and stepmother left Cinderella, she started to cry. She wanted to go with her step-mother and step-sisters. All of a sudden a big puff of smoke filled the air and here I am. I said that I was her fairy god mother. I am going to help her go to the ball and dance with the prince for the whole night. But as Cinderella turned her head I saw how desperate she really was. But I felt that a man just wants someone to do their dishes and their dirty work for them. Still, she was deeply in love. This was where the magic comes in. I took the apple from the table and waved my magic wand above my head and the apple turned into a magical carriage. I took my magic wand and waved it over Cinderella's head and said, "Turn this filthy little maid into a beautiful princess." I took the ants off the other fruit and turned them into horses for the ride there. I looked at her. She was the most beautiful woman I ever saw. Then Cinderella asked, "Why didn't you come before?" "I was busy babysitting Goldilocks." Then Cinderella and I stepped into the carriage, and we rode into the night. On the way there I told her that she would have to be back by midnight, or the magic will wear out, and she would be the same dirty little girl that she was before. When they got there I changed her ugly step-sisters and stepmother into frogs. Cinderella danced with the prince for the rest of the night. The next day they got married. They lived happily ever after.

5. Multilayered narrative with connected episodes. Character and setting description are detailed and sometimes symbolic to reveal intention, motivation, and integration of individuals with time and space. There is evidence of some risk taking in plot manipulation (e.g., efforts to foreshadow or embed subplots) and experimentation with language (e.g., figurative language, word play).	Once there was a king and queen who lived in a golden castle of great beauty, but they had no children. Finally, they had a daughter. They had a splendid feast and they invited all the fairies to court except the eldest fairy because she was a wicked witch. When it was time to give the wishes, the eldest fairy stormed in and said, "I curse the child!" Her voice sounded like stones falling from a cliff. "She shall be ugly and when she is fifteen she shall look into a mirror and die!" After the wicked witch left, the youngest fairy said, "She shall not die, but just faint for 100 years. However, I cannot change the ugliness. My little wand cannot overpower the eldest fairy." So the king broke all the mirrors in the castle. As the ugly princess grew up, it was very hard because everybody in the court teased her. Yet, the servants in the castle loved her as they would their own daughter. Time went by and the ugly princess turned fifteen and she decided that she would explore the castle. She went into a tower and there she saw an old woman putting clips into her hair while staring into an odd square of glass that reflected the old woman's face. The ugly princess said, "May I try?" She took a clip, and when she stepped before the mirror, she saw her horrible face and fell in a faint to the floor. The witch laughed and said, "I've got you now!" Soon, however, the little fairy came and picked up the princess and laid her on a little bed where she slept for a hundred years. But the wicked witch's magic was so powerful that everyone in the castle fell asleep too. At the end of the hundred years, an unattractive prince was riding by on a disgusting-looking horse, when he chanced to see a torn up flag fluttering from the tip of a distant tower. Then he stopped and remembered a story he had heard when he was only a boy about an ugly princess. Since he hadn't had any luck with beautiful princesses during his journey, he decided to try an ugly one. He went into the quiet castle. His footsteps echoed in the halls. Nothing stirred. He felt like the walls were holding their breath. Then he saw a tiny stairway and climbed it to the tower room. When he entered the room, he saw the Sleeping Ugly. He bent to kiss her, but then he stopped and said, "Should I be doing this." But then he decided even though she was ugly on the outside, she was probably very beautiful on the inside. He kissed her and she woke up. They were married in a beautiful green meadow with daisies all around. They had two ugly children and they lived happily ever after in a castle without mirrors for the rest of their lives.
6. A rich and multilayered narrative with fully integrated, often multifunctional components, and considerable orchestration in communication to illuminate the components. Growth in characters, purposeful point of view, variety of plot techniques, crafted choice of language.	No example provided.

Appendix D: Fluency Task

Name _____

The quick brown fox jumps over a lazy dog.

Appendix E: Lesson Plans

Session 1: Cognitive Load Assessments – Classroom Activity

Total lesson time 30 minutes.
Materials:

- Handwriting fluency assessment page for each student
- Paper for spelling assessment for each student

Words in italic are said by the researcher.
Today we are going to do handwriting and spelling assessments. I want to learn how quickly you can write and how you spell tricky words. For the handwriting activity, you are going to write the sentence "The quick brown fox jumped over a lazy dog" As many times as possible in 2 minutes. Be careful when you are writing, make sure I can read what you write. Remember if you make a mistake, just cross it out. I am going to pass out the papers, do not start until I say start.

Write your name and your teachers name on the top of the page. Then, put your hands on your head so I know you are ready. When I say start, write "The quick brown fox jumped over a lazy dog." As many times as possible in 2 minutes. I will demonstrate on my own paper. Watch me. Write the sentence one time and stop. *Now my teacher hasn't told me to stop, so I am going to keep writing.* Write the sentence again. *The teacher still hasn't told me to stop, so I will keep writing. When you are writing at your seats, keep writing the sentence again and again, until I say stop. Be careful when you are writing, so I can read it. Keep writing until I say stop. Ready, start.*
Time students for 2 minutes.
Stop. Hands on your head. I am going to collect your papers.

Now we are ready for the spelling assessment. I want to learn how well you spell when your write. You haven't practiced these words and this test is used with kids in high school too, so the words are really tricky. I want you to try your best. I am going to read some words to you, and I would like you to write each one on the line beside the numbered space. Listen carefully so you hear each word I say. Then try to spell the word correctly. I will say the word, then read a sentence with the word in it and then say the word again. Please write the first word here. Then, go down the page this way as I say each word. Try to do your best. If you are unsure how to spell a word, you may take a guess. I am going to pass out your spelling papers. Please write your name and your teachers name on the top of the page using your pencil.

I want to remind you that this is a really tricky spelling test. It goes from second grade all the way to high school, so some of these words are REALLY hard. I want you to give me your best guess on how to spell any words you don't know.

Read the first 25 green spelling list with sentences. Score these and then pull any students who have not missed 10 words in a row to finish the assessment.

Thank you. I am going to collect your papers.
Session 2 – Introduction to Word Processing – Computer Activity

- how to save a document
- type text with capitals and spaces
- delete text using the delete and backspace keys
- correct misspelled words that have red squiggly line with a right click

Total lesson time 30 minutes.
Materials:

- Model computer with projector
- Computer for each student
- Class folder with blank document for each child saved under child's name comp 1

Word in italic are said by the researcher. Words in {} are typed.

Hi boys and girls, I am Mrs. Lisy. Today we are going to learn about typing on the computer. I am going to show you on the screen and then you will have a chance to write your own story. We are going to learn how the computer can help us spell words and how to type using capital letters and punctuation marks. I have already created new pages for you on the computer. I am going to click on folder (name of folder on the students' computer). Now I am going to click two times fast on your teacher's name and find my name Mrs. Lisy and click two times fast again.

Students' Documents

Name Teacher   Becuz

What I will say	What the screen will show
First I am going to type my name next to "Name". To make the capital letter at the beginning of my name, I am going to hold down the shift key and press the letter M. Now I am typing "rs" "period" for the abbreviation Mrs. The period is located 2 to the right spaces right of the letter M. Then I need to add a space using the space bar. Remember the spacebar is the long bar at the bottom of the keyboard. To get to the next line I press the "enter" key. I am going to type your teacher's name on the next line. So I know whose class I was in.	Name Mrs. Lisy Teacher {teacher name}
Now you can see the word because here, but it looks strange. It has a red squiggly line under it. That means that it is not spelled correctly. One thing you need to know about computers is they	Because

don't know everything. Look at my name, Mrs. Lisy. There is a red squiggly line under Lisy. Do you think I know how to spell my own name? I do, but the computer doesn't. So sometimes the spell check is wrong. But because is spelled wrong, so to fix it I am going to right click. Hold up the mouse and point to the right mouse button. Then, read list of words that appears. *Here is because. I will click on because. Now I want to see that you can fix words that aren't spelled correctly, so when you are typing just leave the because on the top line and write about yourself below.*	
Now I am going to write a few sentences about myself. I am going to start my sentence with "I" to make a capital I, I hold the shift key while pressing the letter I. {I amm} oops, I accidently pressed the m key twice. To erase the extra M, I am going to use the "backspace" button to delete. Backspace is located near the top right on the keyboard. (press backspace to demonstrate). {a techur}. That is strange why does that have a red squiggly line under it. I must have spelled the word incorrectly. Just like before when we fixed because, I am going to right click with the mouse. It gives me these choices: teacher, etcher, tether, techier, recur. I am going to pick the first one "teacher." If you think a word is correct you can ignore it, if you aren't sure you can right click to see if it has any spelling suggestions for your word.	I am a techur. I have a litle boy named Will. I like reding.
I am going to keep typing. {I have a litle}. There is that red squiggly line again. I am going to right click and pick the word little. {boy named} My son's name is Will. I need to make his name capital. So I am going to hold down the shift key while pressing W. {Will. I like reding.} Wow! I am really having trouble spelling today. I am going to right click again and look for reading. (read choices and select reading) Sometimes the correct spelling may not be the first word. Read through the list to find the word you need. And remember the computer does not know everything and sometimes it can be wrong. I am going to reread my writing "I am a teacher. I have a little boy named Will. I like reading." You know I want to change my last sentence. I do like to read, but I like to travel more. So I am going to use my mouse to highlight the word "reading." I am going to put my mouse at the end of the word reading then I am going to hold down the left mouse button and drag the cursor to the beginning of the word "reading" now that the word is highlighted. I am going to press the backspace key to delete the word. Now I am go to type {to travel!} I really like to travel, so I am going to use an exclamation point. That is a tricky punctuation mark to find. It is above the number 1. So I press the shift key and the number 1 to make an exclamation point.	I am a teacher. I have a litle boy named Will. I like reding.

Now I am finished with my sentences because I want you to have a chance to do some writing. Quickly, I want to remind you about how to delete a letter or word. Make sure your cursor is

next to the letter or word you want to delete. Press backspace. To correct the spelling of a word, right click on a word with red squiggly line and pick the correct spelling. I know you are in second grade and I don't expect you to know how to spell every word, but this can help you. Now I am going to save my work. I am going to click on "File" at the top of the page then click "Save." You are going to go to your computers and write about yourselves. I don't know anything about you. What do you like to do? What don't you like? How old are you? Anything you want me to know about you.

Now you can go to your computers.

To open your document, click two times fast on folder (name of folder on students' computers), now click two times fast on your teacher's name, now find your name and click two times fast to open your page.

Type your name on the top of the page. Now press "enter" and type your teachers name on the next line. Now right click on becuz. Select because from the list. Now go to the next line and start writing about yourself.

Students will have 10 minutes to type. I will walk around and help students as they are practicing. I will model or offer assistance as needed because the goal of these lessons is exposure to a word processor. Then, I will ask them the following questions.

Raise your hand if you have typed a capital letter. Raise your hand if you have used a period or exclamation point. Raise your hand if you have changed the spelling of a word with a red squiggly line.

If all of the students have indicated they have done those things, then the questions about snow will be reread and they can continue writing. If it is 1-3 students, I will model individually. If it is more students, then I will reteach.

Students will have 5 more minutes to type.

You have one minute left. Finish the sentence you are working on and we will save your documents. Click on "file" at the top of the page. Then click on "Save."

Session 3 – Introduction to Word Processing Continued – Computer Activity

Cognitive Load Assessment:

- Typing assessment

Introduction to Word Processing

- review previously introduced skills (see session 1)
- copy and paste text from one section of the document to another

Total Lesson Time 30 minutes
Materials:

- Model computer with projector
- Computer for each student
- Copy and Paste Handout
- Class folder with typing assessment for each child saved under each child's name saved under child's name typing
- Class folder with blank document for each child saved under child's name comp 2

Word in italic are said by the researcher. Words in {} are typed.

Today I want to learn more about you. First, we are going to do a typing activity. Then, you will have a chance to do some more writing. For the typing activity, you are going to type the sentence "The quick brown fox jumped over a lazy dog" As many times as possible in 2 minutes. Be careful when you are typing. Do not start until I say start.

Now click on folder (name of folder), click on typing folder, and click on your name. Click next to "Name" and type your name and your teacher's name. Then put your hands on your head so I know you are ready. When I say start, click underneath the sentence and type "The quick brown fox jumped over a lazy dog." As many times as possible in 2 minutes. I am going to show you how I want you to type the sentence. I will type the sentence one time and stop. *Now I have finished typing the sentence one time, but I still have more time, so I am going to type the sentence again.* Type sentence again. *Now I finished the sentence again, but I still have more time, so I am going to keep going.* Start typing sentence again. *Now my teacher says stop. Now it is your turn to show me how quickly you can type the sentence. If you finish your sentence before, I say stop, then type the sentence again. Be careful when you are typing. Keep typing until I say stop. Ready, start.*
Time students for 2 minutes.
Stop. Now we are finished. Click on "file" and "save." To save your work.

Now we are going to do some more writing. Yesterday we learned how to change the spelling of a word with a red squiggly line. Today we are going to learn how to copy and paste words and sentences. Pass out Copy and Paste Handout.

I already wrote something to work on today. (read text aloud)

*{*Snowy days are my favorite. I buld big ones and little ones. I make entire snow families in my backyard. I give them carrot noses and eyes button.}

First thing I notice is I have a red squiggly line under build. I will right click that to find the right spelling. I also noticed that I forgot to tell the reader what I was building. I think that it makes more sense if it says. Snowy Days are my favorite. Then I say that I make snow families. Then I say that I build big ones and little ones. To move an entire sentence, I have to highlight it. Look at number one your paper. It shows you a picture to remind you how to highlight. So I am going to highlight, "I make entire snow families in my backyard." I put my cursor at the end of the sentence and hold the left button down while I highlight the whole sentence. Number two shows how to cut. I right click "cut." Number three says that I put my cursor where I want the words to go. I put the cursor before the sentence about building big ones and little ones. Number four, I right click and click on the first clipboard under the word paste  *. Look at your paper, see it has a picture of a paintbrush. Now I am going to read my story again "Snowy days are my favorite. I make entire snow families in my backyard. I build big ones and little ones. I give them carrot noses and eyes button." Ooh, I see another thing that doesn't make sense. I need to switch eyes and button. I am going to highlight "eyes" and right click "cut" and then I am going to put my cursor after button and right click the first clipboard under paste. Now I am going to read my story again. I like that much better.*

Now we are going to our computers. Click on folder (name of folder on desktop,) teacher's name, "computer," click on your name.

Students' Documents

Teacher C Name Lisa

That is funny, your name is already filed in and so is your teacher's name, but they aren't in the correct order. We will have to copy and paste to fix it.

First, highlight the words Name and your name. Do this by holding down the left mouse button. When it is highlighted, right click and select Cut. Now, put the mouse where you want the words to go. So click in front of Teacher C. Now right click and select Paste, the picture with the paintbrush. Now that is fixed. For each step, the teacher and researcher will make sure each student is able to do it before moving on to the next step in the cut and paste process.

Now that you have your paper ordered correctly, you can write about snow. Read the questions from the prompt on the board:

> *"Snow*
> *What do you like about snow?*
> *What don't you like about snow?*
> *What do you do on snowy days?"*

Students will have 8 minutes to work on their stories. The teacher and researcher will walk around and help students as they try to move words or sentences.

We only have a few minutes left. Raise your hand if you were able to move a word or sentence. I want everyone to have a chance to move a word or sentence.

Now we are going to save our stories. Click "file" and "save.

Session 4 – Spelling and Text to Edit Assessments – Computer Activity

Materials:

- Paper with directions for "Text to Edit"
- Copy and Paste Handout
- Class folder with spelling page for each child saved under child's name spelling
- Class folder with text to edit page for each child saved under child's name edit

Word in italic are said by the researcher. Words in {} are typed.
This lesson is different from the previous computer training sessions. It takes place with two short pull out sessions: one small group and one individual.

Spelling Assessment: Pull 3-4 students out at a time to complete the assessment. Students will be randomly selected and allowed to go back to class as soon as they spell 10 words in a row incorrectly.
Today we are going to do a spelling assessment so I can learn how well you spell using the computer. This is just like the assessment we did on in class using paper and pencil a few days ago. You haven't practiced these words and this test is used with kids in high school too, so the words are really tricky. I want you to try your best.

First, we have to open our spelling page. Click two times fast on (folder name), click two times fast on your teachers name, click two times fast on spelling, then click two times fast on your name. Type your name on the top line and your teacher's name on the next line. Click next to the number 1 so you are ready to begin. I am going to read some words to you, and I would like you to type each one on the line beside the numbered space. Listen carefully so you hear each word I say. Then try to spell the word correctly. I will say the word, then read a sentence with the word in it and then say the word again. Please type the first word next to the number 1. And then press enter to go down the page as I say each word. Try to do your best. If you are unsure how to spell a word you may take a guess. You can also use the red squiggly lines to help you. If there is a word with a squiggly line, you can right click and select the word you think is right. Remember the computer doesn't know everything and sometimes it doesn't know how to spell words correctly.

I want to remind you that this is a really tricky spelling test. It goes from second grade all the way to high school, so some of these words are REALLY hard. I want you to give me your best guess on how to spell any words you don't know.

Read blue spelling list with sentences. As students spell 10 words incorrectly in a row, send them back to class.

We are going to save our spelling lists. Please click "file" at the top of the page then click "save."

Computer Skills and Access Assessments: After all of the students have completed the spelling assessment. Pull students one at a time to complete this task. First, ask the computer access questions. Then, complete the Text to Edit task.

First, I am going to ask you a few questions about computers at your house.

7. Do you have a computer at home?
8. How often do you use the computer? Daily, A few times a week, Weekly, Monthly, Rarely
9. What do you do on the computer? Do you: Play games, Visit websites, Email, Chat, Write stories, or Take pictures?
10. Do you have a mobile device you are allowed to use like a: Cell phone, IPad, Kindle, Nook, Tabeo, Leappad
11. How often do you use the mobile device?: Daily, A few times a week, Weekly, Monthly, Rarely
12. What do you do on the mobile device?: Do you: Play games, Visit websites, Email, Chat, Write stories, or Take pictures?

Then, we are going to an activity where you help me fix a story that needs some work.

Now we have to fix this silly story. There are lots of mistakes. We are going to read these directions and make the changes to the story to make it better.

Pass out directions.
Now we are going to double click to open your stories to edit. Click on folder, teachers name, edit, and then click on your name.

First, I will read you the story. Then, I will read the directions one at a time and give you a chance to do what it says.

Directions:

5. *Type your name on the top line of the page.*
6. *Fix the spelling of any misspelled words.*
7. *Make sure every sentence begins with a capital letter.*
8. *Cut and paste the sentence "The End." So it is after the sentence, "The dragon decided to share the cookies."*
9. *Save your fixed document.*

Thank you. The next time I see you we will be writing stories, so come up with some ideas for exciting adventures.

Writing Session 1 and 3 – Classroom Activity

Total lesson time 40 minutes.
Materials:

- Planning page
- Writing paper
- Drawing paper
- Pencils w/o erasers

Words in italic are said by the researcher.
When we work together, we are going to use pencils that do not have erasers. I want to see all of your thoughts on the paper. If you make a mistake, just cross it out and keep going. I don't mind cross outs it teaches me about how you think.

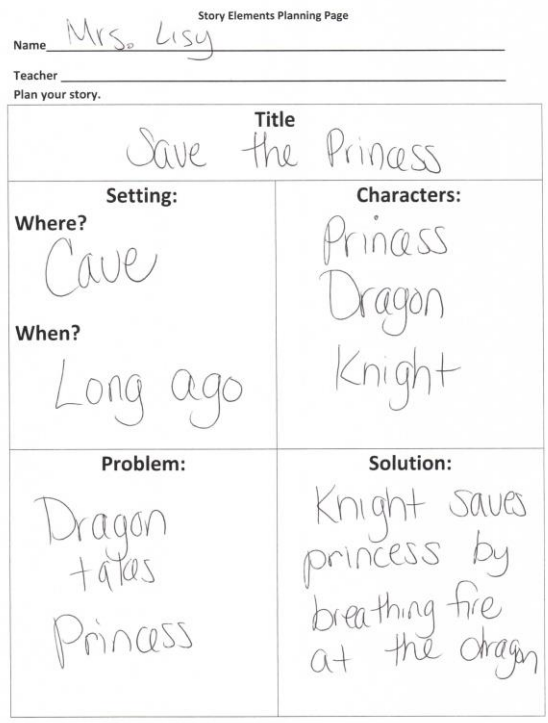
Today we are going to plan and write a story. Sometime you can take days to write a story, but this is a one day story. We want our stories to be really interesting so that others want to read them. I know you have been writing realistic fiction during your writing time, you can write realistic fiction or any other type of story you want. If you want you can write about dragons, princess, and a time long, long ago, or about an exciting soccer game, or anything else you are interested in. You want to make your story exciting.

We are going to start by filling out this story planning page. It will help you come up with some ideas for your story. You need to think about: What is the problem? Who are the characters? How are they going to solve the problem? Is your story going to have a bad guy?

This is our planning page (show planning page). *At the top you will write your name and your teacher's name. Then, you will fill out the details of your story. You don't have to write complete sentences, just a few words about your ideas.*

Session 1
*For example, if I am writing a story about a dragon who takes a princess. So I wrote dragon takes princess for my problem. The solution is going to be the knight saves the princess by breathing fire at the dragon. So my characters are the knight, princess, and dragon. My setting is the cave and long ago. My title is Save the Princess. (*Show my completed form.) *Remember when you fill these out you don't have to write in complete sentences. You can just write a few words so you get your ideas down.* See planning page below.

Session 3
For example, if I am writing a story about a mean girl on the playground. I would write playground and now for setting. The names of the characters: Sara and Lisa. The problem is Lisa is mean to Sara. The solution is Sara invites her to play. My title is Playground Meanie. (Show completed form). *Remember when you fill these out you don't have to write in complete sentences. You can just write a few words so you can get your ideas down.* See planning page below.



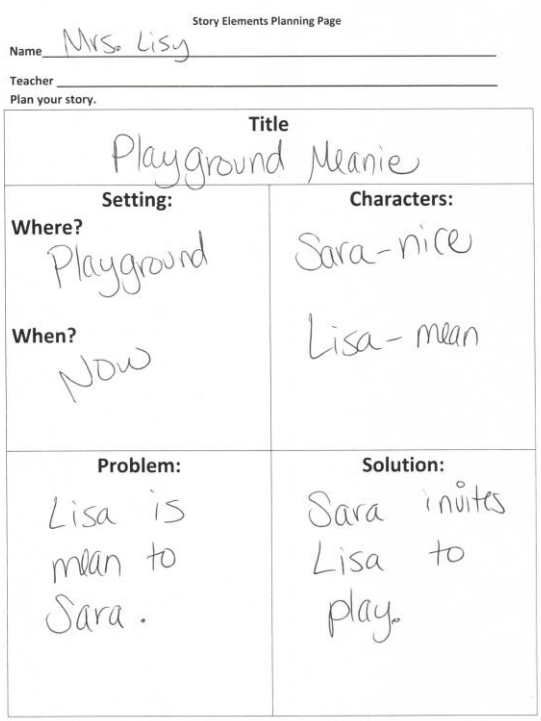
Story Elements Planning Page

Name Mrs. Lisy

Teacher

Plan your story.

Title: Save the Princess	
Setting: Where? Cave. When? Long ago	**Characters:** Princess, Dragon, Knight
Problem: Dragon tates Princess	**Solution:** Knight saves princess by breathing fire at the dragon



Story Elements Planning Page

Name Mrs. Lisy

Teacher

Plan your story.

Title: Playground Meanie	
Setting: Where? Playground. When? Now	**Characters:** Sara-nice, Lisa-mean
Problem: Lisa is mean to Sara.	**Solution:** Sara inuites Lisa to play.

Pass out the papers and pencils w/o erasers. *You have 8 minutes to plan your story.* … Give 2 minute warning. *You have 2 minutes to finish planning.*

Now you are going to write your story. We only have 25 minutes to write today. Make sure you are focused on your writing and add many interesting details. Use your planning page if you get stuck. If you make a mistake, then just cross it out. I will let you know when you have 5 minutes left. I will pass out the papers; write your name and teacher's name on top. Then, wait for me to tell you to start. (pass out papers) *You can start.*

You have 5 minutes to finish your stories.

You have 1 minute, so finish your sentence.

Time is up. Pencils down. Now we collect your stories. Tomorrow we will be revising these stories (on the computer/ in our classroom). Thank you for working so hard.

If students finish early, they can draw a picture to illustrate their stories.

Writing session 2 – Classroom or computer depending on class

This session varies depending on condition. Two classes edit on the computer first, and two classes edit on paper first. Below are lessons for both conditions.

Total lesson time 40 minutes.
Materials for classroom

- First draft
- Writing paper
- Revision questions
- Blue pens
- Example story written on board

Materials for computer

- Researcher typed first drafts
- Revision questions

Words in italic are said by the researcher.

Computer group first
Today we are going to revise our stories. We are going to use our Writer's Questions to help us. Yesterday I wrote my own story based on my planning page. I am going to model how we use our questions to revise our stories, then you will be able to revise your own story.

Here is the story I wrote (read aloud to students while it is on the projector for them to see):
Once upon a time a dragon took the princess to his cave. Everyone was scard, but a knight said he would save the princess. The knight went and told the dragon to let the princess go. the dragon breathed fire The knight had magical powers. he breathed fire at the dragon. The dragon was so scared he let the princess go. And the prince and the princess lived happily ever after.

I am going to look at the first question, "Does it make sense? How can I fix it" When I reread the story, I noticed that I wrote that the prince and the princess lived happily ever after, but there isn't a prince in this story, so I am going to click next to prince and use the backspace key to delete prince. Now I am going to type knight.

The second question "Can I add any details or Juicy words?" I think I want to add beautiful to describe the princess. So I am going to put my mouse before princess and type {beautiful}.

The third question "Can my reader form a clear picture?" I am going to reread my story and think about that…. (reread text aloud to students) I want my reader to know more about the cave. I will use my mouse to put the cursor after the first sentence and type {The dark cave was at the top of a foggy mountain.}

The fourth question "Do I need any capital letters?" I am going to look though my story again. I noticed that I don't have a capital at the beginning of "the dragon breathed fire." So I am going to click next to the t and use the backspace key to delete the lowercase t. Then I am going to hold

down the shift key make a capital t. I also forgot to make the "he" at the beginning of the next sentence capitalized. So I am going to put the mouse next to the h and delete it. Then I will hold down the shift key and press the h to make it a capital letter.

The fifth question "Does each sentence end with correct punctuation?" I am going to reread it and look for places that I pause when I read. (read aloud pausing at the end of each sentence). Oooh. I am missing a period at the end of "Once upon a time a dragon took the princess to the cave" So I am going to use my mouse to put the cursor there and press the period button. Also, I want to make the ending more exciting. So I am going to add an exclamation point after "And the prince and the princess lived happily ever after!"

The last question is "look at each word to see if it is spelled correctly. I noticed that there is a red squiggly line under scard. I am going to right click and see if that helps me spell the word. Oh there it is s-c-a-r-e-d. I forgot the e. I am going to click on "scared" to fix my spelling.

After I go through all of my questions I reread my story one last time and see if it is how I wanted it to be. {reread story one last time}. I like how it sounds, so I am finished with my story.

Now you are going to have a chance to work on your stories. Last night I typed them in the computer exactly as you wrote them. I want you to read the "Writer's Questions" and reread your story to see what changes you want to make. Remember you want your story to be interesting. Read one question then look at your story, and make any changes you want to make. Then, read the next question and see if you want to make any changes.

To open your stories, we have to double click everything again. Double click on folder, teacher name, story, then double click on your name. Make sure you use your writer's questions to help make your story better. Think about your reader and make it really interesting! You have 25 minutes to work. I will give you a warning when you have 5 minutes left.

5 minutes until we have to save our work.

1 minute left. Finish the sentence you are working on and then we are going to save.

Click on file, click on save. Thanks for all of your hard work. I will be back tomorrow so we can write another story together.

Paper Group first

Today we are going to revise our stories. We are going to use our Writer's Questions to help us. Yesterday I wrote my own story based on my planning page. I am going to model how we use our questions to revise our stories, then you will be able to revise your own story.

Here is the story I wrote (read aloud to students from the chart paper with the story):

Once upon a time a dragon took the princess to his cave Everyone was scard, but a knight said he would save the princess. The knight went and told the dragon to let the princess go. the dragon breathed fire. The knight had magical powers. he breathed fire at the dragon. The dragon was so scared he let the princess go. And the prince and the princess lived happily ever after.

I am going to look at the first question, "Does it make sense? How can I fix it" When I reread the story, I noticed that I wrote that the prince and the princess lived happily ever after, but there isn't a prince in this story, so I am going to cross out prince and put a carrot and write prince above it.

The second question "Can I add any details or Juicy words?" I think I want to add beautiful to describe the princess. So I am going to put a carrot before princess and write {beautiful} above it.

The third question "Can my reader form a clear picture?" I am going to reread my story and think about that…. (reread text aloud to students) I want my reader to know more about the cave. So I am going to write put a carrot after the first sentence and add {The dark cave was at the top of a foggy mountain.}

The fourth question "Do I need any capital letters?" I am going to look though my story again. I noticed that I don't have a capital at the beginning of "the dragon breathed fire." So I am going to cross out the lowercase T and write a capital T above it. I also forgot to make the "he" at the beginning of the next sentence capitalized. So I am going to cross out the lowercase h and write a capital h above it.

The fifth question "Does each sentence end with correct punctuation?" I am going to reread it and look for places that I pause when I read. (read aloud pausing at the end of each sentence). Oooh. I am missing a period at the end of "Once upon a time a dragon took the princess to the cave" So I am going to put a period at the end of the sentence. Also, I want to make the ending more exciting. So I am going to add an exclamation point after "And the prince and the princess lived happily ever after!"

The last question is "look at each word to see if it is spelled correctly". I noticed that the word scard looks funny. I can look around the room at the word wall to see if anything helps me. I

think I am missing an e. So I am going to change it to "scared" by crossing out scard and writing scared above it.

After I go through all of my questions I reread my story one last time and see if it is how I wanted it to be. {reread story one last time}. I like how it sounds, so I am finished with my story.

Now you are going to have a chance to work on your stories. I want you to read the "Writer's Questions" and reread your story to see what changes you want to make. Remember you want your story to be interesting. Read one question then look at your story, and make any changes you want to make. Then, read the next question and see if you want to make any changes.

You are going to use a blue pen to make changes to your stories. Then, I will give you new paper to copy your stories for the final draft. Make sure you use your writer's questions to help make your story better. Think about your reader and make it really interesting! Now I will pass out your stories and pens. You have 25 minutes to work. I will give you a warning when you have 5 minutes left.

5 minutes until we have to save our work.

1 minute left. Finish the sentence you are working on and then we are going to stop.

Thanks for all of your hard work. I will be back tomorrow so we can write another story together.

Writing session 4 – Classroom or computer depending on class

This session varies depending on condition. Two classes edit on the computer second, and two classes edit on paper second. Below are lessons for both conditions.

Total lesson time 30 minutes.
Materials for classroom

- First draft
- Writing paper
- Revision questions
- Blue pens
- Example story written on board

Materials for computer

- Researcher typed first drafts
- Revision questions

Words in italic are said by the researcher.

Computer second group
Today we are going to revise our stories. We are going to use our Writer's Questions to help us. Yesterday I wrote my own story based on my planning page. I am going to model how we use our questions to revise our stories, then you will be able to revise your own story.

Here is the story I wrote (read aloud to students while it is on the projector for them to see):
Every day at reces Lisa was mean to Sara. One day Sara watched her, and she saw Lisa didn't have anyone to play with. Sara realized Lisa just wanted a friend. So Sara walked right up to Lisa and asked her to swing Lisa was shocked. no one ever invited her to play. From that day on, Sara and sara were friends.

I am going to look at the first question, "Does it make sense? How can I fix it" When I reread my story I noticed that I wrote "Sara and Sara were friends. I meant to write "Lisa and Sara were friends. So I am going to click next to Sara and use the backspace key to delete Sara. Now I am going to type {Lisa}.

The second question "Can I add any details or Juicy words?" I think I want to add to best because now they are best friends, not just friends. So I am going to put my mouse before friends and type {best}.

The third question "Can my reader form a clear picture?" I am going to reread my story and think about that…. (reread text aloud to students) When I reread the story, I noticed the reader doesn't know how Lisa was mean to Sara. So I am going to take my mouse and click after the word Sara, so I can add some words. I am going to type {She pulled Sara's pigtails.}

The fourth question "Do I need any capital letters?" I am going to look though my story again. I noticed that I don't have a capital at the beginning of "no one ever invited her to play." So I am

going to click next to the n and use the backspace key to delete the lowercase n. Then I am going to hold down the shift key make a capital n. I also forgot to make the "sara" capitalized because it is a name. So I am going to put the mouse next to the s and delete it. Then I will hold down the shift key and press the s to make it a capital letter.

The fifth question "Does each sentence end with correct punctuation?" I am going to reread it and look for places that I pause when I read. (read aloud pausing at the end of each sentence). Oooh. I am missing a period at the end of "Every day at recess Lisa was mean to Sara" So I am going to use my mouse to put the cursor there and press the period button. Also, I want to make it more exciting. So I am going to add an exclamation point after "No one ever invited her to play!"

The last question is "look at each word to see if it is spelled correctly. I noticed that there is a red squiggly line under recess. I am going to right click and see if that helps me spell the word. Oh there it is r-e-c-e-s-s. I forgot an s. I am going to click on "recess" to fix my spelling.

After I go through all of my questions I reread my story one last time and see if it is how I wanted it to be. {reread story one last time}. I like how it sounds, so I am finished with my story.

Now you are going to have a chance to work on your stories. Last night I typed them in the computer exactly as you wrote them. I want you to read the "Writer's Questions" and reread your story to see what changes you want to make. Remember you want your story to be interesting. Read one question then look at your story, and make any changes you want to make. Then, read the next question and see if you want to make any changes.

To open your stories, we have to double click everything again. Double click on folder, teacher name, story, then double click on your name. Make sure you use your writer's questions to help make your story better. Think about your reader and make it really interesting! You have 25 minutes to work. I will give you a warning when you have 5 minutes left.

5 minutes until we have to save our work.

1 minute left. Finish the sentence you are working on and then we are going to save.

Click on file, click on save.

Thanks for all of your hard work. I will be back tomorrow so we can write another story together.

Paper second group

Today we are going to revise our stories. We are going to use our Writer's Questions to help us. Yesterday I wrote my own story based on my planning page. I am going to model how we use our questions to revise our stories, then you will be able to revise your own story.

Here is the story I wrote (read aloud to students while it is on the projector for them to see):
Every day at reces Lisa was mean to Sara One day Sara watched her, and she saw Lisa didn't have anyone to play with. Sara realized Lisa just wanted a friend. So Sara walked right up to Lisa and asked her to swing. Lisa was shocked. no one ever invited her to play. From that day on, Sara and sara were friends.

I am going to look at the first question, "Does it make sense? How can I fix it" When I reread my story I noticed that I wrote "Sara and Sara were friends. I meant to write "Lisa and Sara were friends." So I am going to cross out Sara. Now I will write a carrot and write {Lisa}.

The second question "Can I add any details or Juicy words?" I think I want to add to best because now they are best friends, not just friends. So I am going to put a carrot before friends and write {best}.

The third question "Can my reader form a clear picture?" I am going to reread my story and think about that…. (reread text aloud to students) When I reread the story, I noticed the reader doesn't know how Lisa was mean to Sara. So I am going to put in a carrot after the word Sara, so I can add some words. I am going to write above the carrot {She pulled Sara's pigtails.}

The fourth question "Do I need any capital letters?" I am going to look though my story again. I noticed that I don't have a capital at the beginning of "no one ever invited her to play." So I am going to cross out the n and write a capital N above it. I also forgot to make the "sara" capitalized because it is a name. So I am going to cross out the lowercase S and write a capital S above it.

The fifth question "Does each sentence end with correct punctuation?" I am going to reread it and look for places that I pause when I read. (read aloud pausing at the end of each sentence). Oooh. I am missing a period at the end of "Every day at recess Lisa was mean to Sara" So I am going to write a period. Also, I want to make it more exciting. So I am going to add an exclamation point after "No one ever invited her to play!"

The last question is "look at each word to see if it is spelled correctly. I think recess looks funny. I am going to use the schedule in the classroom to see how to spell recess. I fotgot the s at the end of the word, so I am going to write an S at the end of recess.

After I go through all of my questions I reread my story one last time and see if it is how I wanted it to be. {reread story one last time}. I like how it sounds, so I am finished with my story.

Now you are going to have a chance to work on your stories. Last night I typed them in the computer exactly as you wrote them. I want you to read the "Writer's Questions" and reread your story to see what changes you want to make. Remember you want your story to be interesting. Read one question then look at your story, and make any changes you want to make. Then, read the next question and see if you want to make any changes.

To open your stories, we have to double click everything again. Double click on folder, teacher name, story, then double click on your name. Make sure you use your writer's questions to help make your story better. Think about your reader and make it really interesting! You have 25 minutes to work. I will give you a warning when you have 5 minutes left.

5 minutes until we have to save our work.

1 minute left. Finish the sentence you are working on and then we are going to save.

Click on file, click on save.

Appendix F: Revision Scoring Guide

Type of transformation	
Type	Definition
Addition	Any unit may be added.
Deletion	Any unit may be deleted.
Substitution	Most often punctuation and words will be substituted.
Rearrangement	Phrases, sentences, and paragraphs will be rearranged.
No change	Same word or phrase written again with no change to spelling or letter case.
Level of language affected by the transformation	
Level	Definition
Punctuation*	Includes beginning, middle, and ending punctuation, and correct punctuation of abbreviations and titles.
Word	Includes proper nouns, abbreviations, etc.
Group	As few as two words should be scored as a "group."
Sentence	Must contain subject and predicate; correct punctuation unnecessary.
Text	A group of sentences.
Object of transformation	
Object	Definition
Semantics	Lexical variations, changes of meaning
Text organization	Primarily operations of segmentation, connection, cohesion
Spelling	Both lexical and grammatical aspects
Case	Change in letter case
Relationship to language conventions	
Relationship	Definition
Conventional transformation correctly carried out - CC	Required by the rules of spelling, syntax, and punctuation that no variation is accepted by authoritative references (*Oxford English Dictionary*) and is correctly carried out
Conventional transformation incorrectly carried out-CI	Required by the rules of spelling, syntax, and punctuation that no variation is accepted by authoritative references (*Oxford English Dictionary*), but is incorrectly carried out
Optional transformation not required by language conventions, carried out correctly – OC	Change not required by rules of spelling, syntax, and punctuation carried out correctly.
Optional transformation not required by language conventions, carried out incorrectly – OI	Change not required by rules of spelling, syntax, and punctuation carried out incorrectly.
Location of transformation	
Location	Definition
Beginning	Occurs before the title of first sentence of the text
Within	Occurs within the text
End	Added to the end of the text

To use the system for coding text transformations, the researcher will identify a transformation a child has made. Each transformation will receive four different codes. The first code is based on the level of language affected by the transformation. This code identifies the level the transformation affected (a) punctuation, (b) a single word, (c) a group of words, (d) a sentence, or (e) a section text longer than a sentence. This can provide the researcher with data about whether students are making changes at the word level or looking across the text to make modifications.

The second code is the type of transformation. An addition could be adding a single word, a period, or even a few sentences. Deletions could be at any level as well. Substitutions could be changing spelling, or punctuation, or a sentence. To be considered a substitution, the original word or sentence must be replaced with a new word or sentence. A rearrangement requires the text order to be changed. This could include changing the order of a sentence or switching two words. Additions and deletions are considered simple transformations; substitutions and rearrangements are considered complex transformations.

The third code is the object of transformation. Three types of object transformations are (1) semantics, (2) text organization, (3) spelling, and (4) case. A semantics transformation can be a meaning change, for example, inserting the word "magical" to describe a castle. The added detail slightly changes the meaning of the text—it is not only a castle; now it is a magical castle. It could also include a lexical variation such as changing the word soda to pop. Text organization transformations include segmentation, connections, and cohesion. Segmentation includes inserting spaces between words, as well as inserting or changing punctuation. Connections can include connecting words or sentences such as adding the word "and" or putting a comma in a list of words. Cohesion can be changes in referencing such as changing a proper noun to pronoun, from "Daniel" to "he" or vice versa. Another example of cohesion the insertion of a conjunction or transition such as "but" or "then." Spelling is the third object of transformation. Spelling can be a lexical or grammatical modification such as correcting an error in tense or changing a misspelling of a word. Case is the final object of transformation. Any change from upper to lowercase or vice versa is captured with this code. This code is included because one of the students' revising questions specifically addresses making changes to letter case. Second graders are learning to use capitals at the beginning of sentences and proper nouns. Computers help them identify where they need to change the case of a letter. If the case of a letter is changed along with spelling, then spelling is coded.

The fourth level of transformation is the relationship to language conventions. This level of coding captures the necessity of the transformation and determines if it was correctly implemented. One code is for a conventional transformation that is correctly carried out; these changes are required by the rules of spelling, syntax, or punctuation and were implemented correctly. For example, changing "The prince goed to the castle," to "The prince went to the castle." The word "goed" is not correct; by changing the word to "went," a spelling and grammatical error was corrected. If the student had changed "goed" to "wented," then it would be coded as conventional transformation incorrectly carried out. Optional transformations are not necessary. An optional transformation could be an addition; for example, changing "the princess" to "the beautiful princess," it is not grammatically or linguistically necessary.

The final level of transformation coding is the location. Capturing the location allows the researcher to identify how students perceive revision. Does it occur at the beginning, within the text or at the end? The first code, beginning, is applied to transformations before the first words of the text, this could be adding a title or if there is not title present adding a new first sentence.

The within code is applied to all transformations made within the body of the text. End is applied to all text added at the end of the story.

Type

Additions

One day 2 Barbies didn't have a perfectly perfect home.

Type	Level	Object	Relationship	Location
Addition	Group	Semantics	OC (Optional Correct)	Within

Adding a period to the end of a sentence

- If the period belongs there CC (Conventional Correct), if not OI (Optional Incorrect)

Type	Level	Object	Relationship	Location
Addition	Punctuation	Organization	CC Conventional Correct	Within

Adding more than a sentence to the end of a story – This should always be coded as optional correct because it is not required by language conventions for a student to add on to the end of the story. Because they are adding to the story the meaning is changing, so it is a semantic change.

Type	Level	Object	Relationship	Location
Addition	Text	Semantics	OC Optional Correct	End

Notes about additions – typically additions are Organization changes ie. adding punctuation or Semantic changes that change the meaning of the text. Just adding the word magical to describe a castle subtly changes the meaning of the story

Deletions

"Batman doesn't talk about Talia and Joker. ~~Harvey Quinn gets her revenge.~~ Robin has to save Batman."

The student deleted the sentence "Harvey Quinn gets her revenge."

Type	Level	Object	Relationship	Location
Deletion	Sentence	Semantics	OC Optional Correct	Within

"They got wooden swords and ~~and~~ killed a giant." This student deleted a double word. This affected the cohesion or flow of the writing, so is coded as an organization change.

Type	Level	Object	Relationship	Location
Deletion	Word	Organization	CC Conventional Correct	Within

"She went to the store~~.~~ for milk." - Student deleted a period that was incorrect.

Type	Level	Object	Relationship	Location
Deletion	Punctuation	Organization	CC Conventional Correct	Within

Notes about Deletions: typically deletions are Organization changes ie. deleting punctuation or Semantic changes that change the meaning of the text.

Substitutions

villag to village

Type	Level	Object	Relationship	Location
Substitution	Word	Spelling	CC Conventional Correct	Within

Fais to Furis – intended word Furious
While this student attempted to correct a misspelled word, their attempt was unsuccessful. Therefore, it is coded as a conventional transformation that was incorrectly carried out.

Type	Level	Object	Relationship	Location
Substitution	Word	Spelling	CI Conventional Incorrect	Within

the to The (at the beginning of a sentence)

Type	Level	Object	Relationship	Location
Substitution	Word	Case	CC Conventional Correct	Within

Change a period to an exclamation point.

Type	Level	Object	Relationship	Location
Substitution	Punctuation	Organization	OC Optional Correct	Within

Notes about Substitutions: The majority of substitutions are spelling or case changes and happen at the word level.

Rearrangements

Draft: "Uh Oh," said Kyra the youngest.
Final: Kyra the youngest said, "Uh Oh."

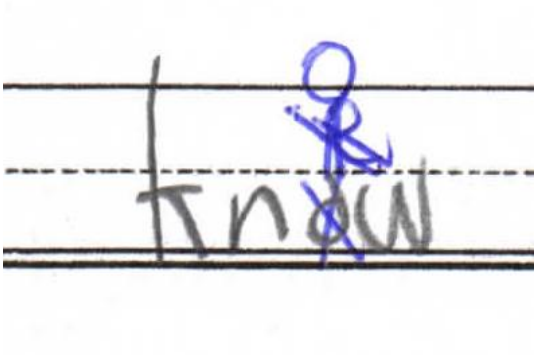
This is an organization change because the meaning is not changed by reordering the words.

Type	Level	Object	Relationship	Location
Rearrangements	Group	Organization	OC Optional Correct	Within

Notes about Rearrangements: This is the least common code. It is difficult to identify at times if it is a rearrangement or a deletion and addition. If the words stay the same but the order is changed then score as a rearrangement.

No Change

No change scores can only be given to handwritten work.
Students recopy the same misspelling when trying to spell a word correctly.
Students trace over a letter to make sure it is legible, but do not change the letter.



In this case the student crossed out the o, wrote an e, crossed out the e, and finally wrote o again. There was no change to the final story.

Level

The tricky part of coding the level occurs when the draft has a change at one level and the final text has a change at another. The default is to code the level of the final change.

Draft: butter fly
Final: butterfly

Type	Level	Object	Relationship	Location
Substitution	Word	Organization	CC Conventional Correct	Within

To code at the sentence level, the student does not have to use correct punctuation, but it must be a full sentence.

Object

Semantics
Any change in meaning, from adding a describing word to a new paragraph is a semantics change.

Text Organization
This is the most challenging to code because it encompasses a large number of items.
Any change to punctuation, spacing, or word order is coded as organization.
Changes to cohesion and connection is included in text organization:
This includes changes in referencing from "The princess" to using her name "Anna." Or "Daniel" to "He"
This also includes changes to conjunctions and transition words in the lists below:

- change in conjunction or transition
    - but, and , so, yet, nor, so

Common Coordinating conjunctions

after although as as if as long as as though because before even if even though	if if only in order that now that once rather than since so that than that	though till unless until when whenever where whereas wherever while

Pasted from <http://grammar.ccc.commnet.edu/grammar/conjunctions.htm>
Correlative conjunctions

both . . . and not only . . . but also not . . . but either . . . or	neither . . . nor whether . . . or as . . . as

Pasted from <http://grammar.ccc.commnet.edu/grammar/conjunctions.htm>

- Coherence Using Transitional Tags

addition	again, also, and, and then, besides, equally important, finally, first, further, furthermore, in addition, in the first place, last, moreover, next, second, still, too
comparison	also, in the same way, likewise, similarly
concession	granted, naturally, of course
contrast	although, and yet, at the same time, but at the same time, despite that, even so, even though, for all that, however, in contrast, in spite of, instead, nevertheless, notwithstanding, on the contrary, on the other hand, otherwise, regardless, still, though, yet
emphasis	certainly, indeed, in fact, of course
example or illustration	after all, as an illustration, even, for example, for instance, in conclusion, indeed, in fact, in other words, in short, it is true, of course, namely, specifically, that is, to illustrate, thus, truly
summary	all in all, altogether, as has been said, finally, in brief, in conclusion, in other words, in particular, in short, in simpler terms, in summary, on the whole, that is, therefore, to put it differently, to summarize

time sequence	after a while, afterward, again, also, and then, as long as, at last, at length, at that time, before, besides, earlier, eventually, finally, formerly, further, furthermore, in addition, in the first place, in the past, last, lately, meanwhile, moreover, next, now, presently, second, shortly, simultaneously, since, so far, soon, still, subsequently, then, thereafter, too, until, until now, when

Pasted from <http://grammar.ccc.commnet.edu/grammar/transitions.htm#transitions>

Spelling

When coding spelling changes watch to make sure you code the relationship correctly.
villag to village

Type	Level	Object	Relationship	Location
Substitution	Word	Spelling	CC Conventional Correct	Within

Fais to Furis – intended word Furious
While this student attempted to correct a misspelled word, their attempt was unsuccessful. Therefore, it is coded as a conventional transformation that was incorrectly carried out.

Type	Level	Object	Relationship	Location
Substitution	Word	Spelling	CI Conventional Incorrect	Within

Case

Case changes often occur at the beginnings of sentences (see Addition examples).

tumBling to tumbling

Type	Level	Object	Relationship	Location
Substitution	Word	Case	CC Conventional Correct	Within

Relationship

First, determine if it a required change and decide if it is a Conventional or Optional transformation. Most semantic changes are optional changes.
Then, determine if it is carried out correctly or incorrectly.

Location

The majority of changes will be within the text.