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Children's use of the spell checker during the composing process

by

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Abstract

The purpose of the present study was to explore children's use of the spell checker during the composing process. Fourth- and sixth-grade students wrote a story using a word processor and corrected their errors. The results from descriptive analyses indicated that participants in both fourth and sixth grades made a variety of errors, such as errors in capitalization, spacing, punctuation, and spelling when writing on the word processor. Further, both grade groups used a variety of methods to correct errors, such as correcting errors themselves, using the spell checker, using a dictionary, switching to a different word, and using a combination of methods. Further, the results suggest that children were generally successful at using the spell checker. In addition, participants from both grades corrected the majority of errors properly and both grade groups' mean success rates for using the spell checker were high. The spell checker frequently suggested the correct spelling for misspellings, and participants tended to use the spell checker most often to correct misspellings and to correct themselves most often to correct the other errors. In addition, when participants used the spell checker, both grade groups were mostly successful at choosing the correct word on the spell checker's list, regardless of its position on the list. Further, typing skill accounted for differences in story length across grade level. The above results provide insight into elementary-school children's use of the spell checker and their own knowledge to correct errors made during composition. Even though the spell checker may be imperfect, children can successfully use this tool to increase their likelihood of correcting misspellings properly.

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"What you are is God's gift to you. What you become is your gift to God." (Anonymous).
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Dedication

"You don't really understand human nature unless you know why a child on a merry-go-round will wave at his parents every time around - and why his parents will always wave back."

-William D.
Tammeus

I dedicate my doctoral dissertation to my parents, Allan and Lalita Figueredo, to the memory of my paternal grandparents, Michael and Blanche Figueredo, and to the memory of my maternal grandparents, Alexander and Phyllis Athaide.

Table of Contents

List of Tables

Children's Use of the Spell Checker during the Composing Process

Introduction

Whether the tool is a sharpened flint or a keyboard, writing is a powerful vehicle. Teaching children how to communicate through writing is one of the major goals of formal education. Effective writing conveys an idea without introducing puzzle or mystery. To do so, the effective writer must use their tool without encountering hindrances. Thus, learning to write includes learning to use writing tools properly.

A key component of learning to write is learning to spell. With the advent of computer use, the writer is invited to adapt his/her craft to a new medium: the word processor with a built-in spell checker. The goal is the same: impeccable spelling. But, the medium introduces new options and challenges to achieving this goal. This circumstance raises the question: In order to support the application of children's writing and spelling skill in a challenging environment, how should children be taught to use the word processor and spell checker?

Although parents may be keen to advocate for the use of tools such as the spell checker (e.g., Learning Disabilities Association of Canada, 2005), it is important to consider whether the use of assistive technology is developmentally appropriate (e.g., Cunningham & Kelly, 1997). The spell checker's limitations include failure to detect some types of errors and failure to offer the appropriate suggestions for error correction. Research is needed on how children use spell checkers despite its limitations so that stakeholders (e.g., children, parents, educators) are in a better position to make evidence-based decisions.

As a starting point to address this issue, in this study, I have focused on the

process by which children use the spell checker during a composition task. Fourth- and sixth-grade students composed a short story using a word processing program on the computer. They were instructed to correct any errors they made and were told that the spell checker and a paperback dictionary were available for their use. In addition, they completed spelling and typing tests as well as a short questionnaire on their computer and writing experience.

Review of the Literature

The review of the literature is selective; studies are reported from the literature in order to provide an overview of the broader context within which the study is situated, to highlight studies that are relevant to key ideas in the study or that directly relate to the dissertation topic, and to serve as a preface to identifying and stating the problem of the present study. Following is a review of the literature on four topics related to this study. First, a review of research on the development of children's writing skill provides a broad context in which the study is situated. More specifically, this is followed by a review of the research on children's spelling skill development. A review of studies on children's writing and spelling skill is relevant because it highlights the knowledge that children bring to the task of writing with a word processor and using the spell checker. In addition, research on children's use of the word processor is reviewed to describe what is known about their tool use, followed by a review of studies investigating children's use of the spell checker. A summary of these studies provides the necessary background for explaining the purpose and contribution of this study.

Research on the Development of Children's Writing Skill

Research on the development of children's writing and revision skills has elicited several trends. In particular, over the period of roughly grades four to nine, different skills related to writing ability tend to develop substantially. For example, children's working memory is related to children's writing ability (e.g., McCutchen, 1994; Swanson & Berninger, 1994), while factors such as self-regulation (e.g., Graham & Harris, 2000) and planning (e.g., Burtis, Bereiter, Scardamalia, & Tetroe, 1983; Fitzgerald, 1987) are related to writing quality of texts.

Topic knowledge also plays an important role in children's writing: it is a primary source for children when composing (Bereiter & Scardamalia, 1987), and it is heavily dependent on when children are trying to revise a text (Butterfield, Hacker, & Plumb, 1994). Based on several studies investigating children's and adults' writing, Bereiter & Scardamalia (1987) described two models of how writers apply topic knowledge when composing. *Knowledge-telling* is a strategy typically used by children where they first identify topics related to the written assignment and then report or "tell" what they know about those topics (Bereiter & Scardamalia, 1987). By contrast, older writers tend to use a *knowledge-transforming* strategy, in which they begin by identifying goals for the written assignment. Then, they use a problem-solving process to tailor the text to reach their goals. This process involves an interaction between topic knowledge and the developing text; that is, knowledge interacts with and is "transformed" by the writing process itself (Bereiter & Scardamalia, 1987). Thus, *knowledge-transforming* allows for a problem-solving interplay between topic knowledge and the constructive process of writing, while *knowledge-telling* is limited to conveying information by simply imparting topic knowledge.

Because the writing process requires much cognitive effort and engages several cognitive processes, children are likely to encounter challenges and problems with several aspects of the writing process. For example, children have difficulty with both detecting (Beal, 1990) and diagnosing how to correct problems with the text (Scardamalia & Bereiter, 1983). Some researchers have suggested children's egocentrism is related to their difficulty with problem detection (e.g., Kroll, 1978), because they may have trouble taking the audience's perspective in order to improve the text's clarity. However, the empirical support for this suggestion is mixed (Fitzgerald, 1987). Transcription can also interfere with the writing process, such as planning and revising (Graham & Harris, 2000). In addition, executive control and working memory processes are limited in novice writers (e.g., McCutchen, 1994; Scardamalia & Bereiter, 1983). For example, while revising just one sentence, children may experience great difficulty in managing and preserving the sentence's central idea (Scardamalia & Bereiter, 1983). Finally, when children do revise, their revisions do not always have a positive impact on the text's quality (e.g, Fitzgerald, 1987).

Much research on revision has shown that children of all ages do not tend to revise their texts much, and when they do revise, their revisions are mostly at the surface level (see Fitzgerald, 1987, for a review). However, children's competence at revision does improve with age and researchers have found several developmental trends related to children's revision skill. Older children make more content revisions (e.g., Fitzgerald, 1987) and are also better at detecting incongruencies in text (Beal, 1990) than younger children are. One explanation is that younger children overestimate the informativeness of a text and so they are more likely to let problems or ambiguities go undetected (Beal,

1990). However, on the occasions when they do spot problems, younger children are as likely to revise the text appropriately (Beal, 1990).

In addition, older children's choices for text revision tend to match more closely with advanced writers, compared to younger children's choices (Scardamalia & Bereiter, 1983). Finally, while most research has focused on revisions that occur on the product itself, there is evidence that even younger children, like older children and adults, plan and make some online revisions in their head before transcription occurs (e.g., Burtis et al., 1983).

Research on the Development of Children's Spelling Skill

Research on the development of spelling skill has been most commonly undertaken by examining children's spelling errors. Several researchers have conducted comprehensive cross-sectional studies of error analyses (e.g., Read, 1975; Treiman, 1993). The analyses of spelling errors across age revealed a pattern that led researchers to describe the development of spelling skill as a series of invariant, successive stages. Several stage theories were suggested to describe the way in which children learned the conventional spellings of words (e.g., Ehri, 1986; Gentry, 1982; Henderson, 1985; Henderson & Templeton, 1986).

Although the theories were subtly different, they tended to emphasize a similar progression. Typically, the first stage was a pre-phonetic stage in which children did not use phoneme-grapheme correspondence rules to produce spellings (e.g., *xl* for *cat*). The following stage, the phonetic stage was marked by the alphabetic principle, a milestone in which children gain an understanding that letters represent sounds. At this stage, children produced invented spellings in which they tried to represent phonemes using

corresponding letters (e.g., *kat* for *cat*). In the orthographic stage, children began to learn about specific spelling rules (e.g., *i* before *e* except after *c*), and these rules influenced the various types of spellings they produced. Sometimes, this influence expressed itself as an overextension of a well-learned rule (e.g., *runned* instead of *ran*). As children became more skilled at producing word-specific spellings, they moved to the retrieval stage in which the majority of commonly used words were spelled correctly, but retrieval did not always ensure a correct spelling.

Several problematic issues arose with the proposed stage models of spelling development. First, it was not clear that all school-age populations (e.g., children with learning disabilities) were passing through the invariant stages in the same order. Second, there was evidence that rather than children being strictly in one stage, their knowledge bases were "straddling" two adjacent stages. This issue is problematic for stage models because in theory children should only be in one stage at a given point in time. Third, the stage models seemed to focus mostly on product, while research using a much more fine-grained analysis of children's spelling was revealing a developmental pattern that could be better captured by a process model (e.g., model of children's strategy use) by explaining the variability both within and across children's spelling error patterns (Varnhagen, McCallum, & Burstow, 1997).

To address these issues and to focus more on process, several studies have been conducted on children's spelling strategies. These studies reveal a pattern of variability in which children have several strategies at their disposal when spelling (Evans & Smith, 1989; Rittle-Johnson & Siegler, 1999; Steffler, Varnhagen, Friesen, & Treiman, 1998; Varnhagen, Boechler, & Steffler, 1999; Varnhagen et al., 1997). These strategies include

phonological, orthographic and morphological strategies, spelling by analogy, visual checking, and retrieval. Further, micro-genetic studies of children's strategy use over time revealed a pattern of "overlapping waves" (Siegler, 1996) in which children continued to use a variety of strategies, but there were frequency shifts in specific strategy use (e.g., more use of retrieval over time) (Rittle-Johnson & Siegler, 1999; Varnhagen et al., 1999). This overlapping waves model has been successfully applied to describe both children's and adults' changes in spelling over time (Kwong & Varnhagen, 2005).

In addition to the process by which children spell, researchers have investigated several factors related to the development of spelling skill. As previously mentioned, children need to grasp the alphabetic principle, an understanding that letters in words represent sounds. Two critical steps toward achieving an understanding of the alphabetic principle are the development of phonological awareness (e.g., Adams, 1990; Muter & Snowling, 1997; Sterling & Robson, 1992; Treiman, 1993, 2000) and letter knowledge (e.g., Adams, 1990, Treiman, 1993, 2000). Specifically, children who have an appreciation for the phonological structure underlying words and who are aware of and can manipulate language (e.g., at the syllabic and phonemic levels), can apply this skill to their invented spellings by sounding out phonemes and providing plausible grapheme correspondences.

In addition to learning about the language's phonological system, children also need to learn the language's orthographic rules and how to incorporate these rules and conventions, as well as exceptions to rules, into spelling. As children have more exposure to the language (e.g., print exposure) and receive formal instruction in

orthographic rules, they begin to rely more on their knowledge of orthography when spelling (Cassar & Treiman, 1997; Griffith, 1991; Varnhagen et al., 1999).

In addition to orthographic knowledge, morphological knowledge is also important to spelling development. For example, morphological knowledge allows children to understand the relations between word families. For example, spelling *sign* from strictly a phonological perspective is unlikely to lead to the correct spelling. However, when one considers that the root word is also found in related words (e.g., *signature, signal*), he/she may favour the morphologically correct spelling of the word. In addition, children develop an awareness of the role of suffixes in determining conventional spellings (Deacon & Bryant, 2005). An awareness of the role of morphemes helps children understand the nature of word-specific spellings and accurately produce spellings of morphologically complex words (Kemp, in press). In addition, there is evidence that the relation between spelling skill and morphological awareness may be bi-directional, in that learning to spell can directly affect acquisition of knowledge about morphemes (Nunes, Bryant, & Bindman, in press). Finally, there is evidence that morphological awareness may contribute to literacy development independent of phonological awareness (Deacon & Kirby, 2004).

Spelling researchers have also investigated the relation between spelling and other literacy skills (e.g., reading). Studies have typically shown a strong positive correlation between measures of reading and spelling ability (around the order of 0.7 – 0.85, Ehri, 1986, 2000). However, there is also considerable research on the potential dissociation between reading and spelling skills. In particular, the population of good readers/poor spellers has been looked at in regard to their unique developmental pattern relative to the

normal population (Ehri, 1986, 2000; Frith, 1980). Researchers have suggested that while these individuals possess sufficient phonological and orthographic knowledge to decode words, they tend to have difficulty with word-specific spellings because of a lack of knowledge of morphological regularities (e.g., Ehri, 1986). Thus, although reading and spelling are closely related, differences in developmental trends suggest that mastery of spelling may present unique challenges.

Finally, researchers have shown that despite the perceived irregularity of the English language, when looking at the statistical properties of its conventional spellings, English does show consistency across spellings. For example, when considering the position of phonemes and its neighbours within the rime of a spelling, spelling consistency is increased (Kessler & Treiman, 2003). Further, there is evidence that children are sensitive to these contextual cues or patterns, and that they use this information when spelling (e.g., spelling consonants based on knowledge of the preceding vowel, Hayes, Treiman, & Kessler, 2006).

Research on Children's Use of the Word Processor

There are several changes in the writing context from the paper to the word processor environment that should be noted. First, the word processor tends to ease the mechanical aspects of revisions and allows for greater flexibility when editing. For example, it allows for re-organization (e.g., large sections of text to be cut and pasted) and for re-writing (e.g., text may be easily deleted or replaced). Second, the visual aspect of writing has changed from text on a piece of paper to text presented on a computer screen. This change increases other people's visibility of the text, and some researchers have suggested this increased accessibility may affect the social context of writing by

facilitating collaboration (Cochran-Smith, 1991; MacArthur, 1988). For example, one study investigated student-computer ratios and found that students in a 2:1 ratio increased their writing quality more than students in either a 1:1 or 4:1 ratio over the school year (Owston & Wideman, 2001). In particular, the students in the 2:1 ratio group assisted each other with technical problems and made helpful comments and suggestions on each other's work. Third, most word processors have tools such as a built-in spell checker and grammar checker that offer support for certain aspects of the writing process, but are limited in their capabilities (MacArthur, 2000). Fourth, the word processor increases the legibility and professionalism of the text (e.g., the writer can print out new copies of their work).

There has been a considerable amount of research comparing the effect of writing with a word processor versus handwriting on paper. The main findings are that children tend to write longer (D'Odorico & Zammuner, 1993; Langone, Levine, Clees, Malone, & Koorland, 1996; Nuvoli, 2000; Owston, Murphy, & Wideman, 1992; Peterson, 1993), revise more for content (Peterson, 1993), commit more errors (D'Odorico & Zammuner, 1993), correct more errors (Daiute, 1986; Nuvoli, 2000), show a more positive attitude toward writing (Owston et al., 1992), and produce texts of better writing quality (Daiute, 1986; Owston et al., 1992) when using the word processor than when writing on paper. However, it should be noted that some studies have found contradictory results – either no significant differences between the word processor and paper conditions (Kurth, 1987) or more positive findings for the paper condition (Hawisher, 1987).[1] Further, researchers have argued that it is not necessarily the word processor, in and of itself, that is the cause of better writing (e.g., Cochran-Smith, 1991). Instead, the effects of student motivation,

time allocation, types of formal instruction, and the social situation are interrelated factors that may be contributing to students' writing performance when using a computer (Cochran-Smith, 1991). Finally, while researchers have reported that children enjoy the writing process on the computer (e.g., Cochran-Smith, 1991), one study found that attitude toward writing, but not attitude toward writing with the computer, correlated with writing quality (Shaver, 1990).

One issue that has arisen from concerns regarding the word processing environment is the impact of keyboard use and the relevance of typing skill. While researchers have suggested that typing skill may be a hindrance to children's use of the word processor, studies have shown that although children may take longer to transcribe their thoughts, they tend to write more when typing on the word processor than when writing on paper (D'Odorico & Zammuner, 1993; Langone et al., 1996; Nuvoli, 2000; Owston et al., 1992; Peterson, 1993). Further, researchers have argued that touch typing skill is not necessary in order to incur the benefits of word processor use (Kahn & Freyd, 1990). However, familiarity with the keyboard was found to be a factor in children's preference with using a word processor (Kahn & Freyd, 1990). In addition, while handwriting speed and typing speed are positively correlated (Kahn & Freyd, 1990), children's handwriting speed generally is significantly greater than their typing speed (Lewis, Ashton, Haapa, Kieley, & Fielden, 1998), and children tend to encounter greater difficulty when typing than when handwriting (Nuvoli, 2000). Thus, typing, as a part of the transcription process, may be an important factor in explaining variability in children's writing performance with the word processor.

Research on Children's Use of the Spell Checker

An important aspect of the writing process involves proofreading the text for spelling errors. To aid with this task, most word processors contain built-in spell checkers. Research on children and adolescents' spell checker use has focused on comparing correction rates of spelling errors in a word processor/checker condition versus a paper/dictionary condition. Generally speaking, studies using this paradigm have found that students' correction rates of spelling errors tend to be significantly higher in the word processor/checker condition than in the paper/dictionary condition. For example, students in elementary school (Langone et al., 1996; Outhred, 1987), junior high school (Daiute, 1986; Owston et al., 1992), and high school (Gupta 1998; Peterson, 1993) as well as learning disabled students (Lewis et al., 1998) all had higher error correction rates when revising their compositions with the spell checker than with a dictionary. In addition, McClurg and Kasakow (1989) found that attitude towards spelling was significantly more positive in a group of students using the word processor than in a group writing on paper.

However, researchers and educators have pointed to the fallibility of spell checkers (MacArthur, Graham, Haynes, & DeLaPaz, 1996; Montgomery, Karlan, & Coutinho, 2001; Pennington, 1993). Problems may be encountered at two points in time: when using the spell checker to detect errors and when relying on suggestions provided by the spell checker for error correction. Specifically, spell checkers fail to detect homophone spellings (e.g., *their* - *there*), and errors that are "real words" (e.g., *form* - *from*). Moreover, spell checkers can generate false positives, which occurs when the spell checker flags a correctly spelled word. False positives occur for words that are not contained in the word processor's dictionary (e.g., technical language, regional variations

in spelling).

Problems with providing appropriate suggestions for error correction occur when the letter string of a misspelling differs substantially from the letter string of the correct spelling (Mitton, 1987). If misspellings are substantially different in letter string from the correct word, this issue can be problematic because many spell checkers use algorithms based on the letter string of the error to suggest corrections. For example, consider the misspellings *caushis*, *caushus* and *cautous* for the word *cautious*. These misspellings differ in the degree to which the letter string matches the letter string of the correct word. The spell checker does not suggest *cautious* for the misspelling *caushis*, but suggests *cautious* in the second position in the list for the misspelling *caushus* and suggests only *cautious* for the misspelling *cautous*. Thus, the closer the letter string of the misspelling is to the letter string of the correct word, the more likely that the spell checker will suggest this word for correction. In addition to failing to provide an appropriate suggestion, the spell checker may also provide inappropriate suggestions. Further, many spell checkers implicitly order their suggestions in list form and the correct suggestion, if listed, may not always be in the first position. Some researchers have suggested that this type of ordinal positioning may be particularly problematic for children, who may rely on the first word suggested in a list (MacArthur et al., 1996).

Two studies have assessed the success of spell checkers in detecting and correcting students' errors. Both studies used corpora of errors committed by students from the learning disability population in grades three through eight (Montgomery et al., 2001) and grades five through eight (MacArthur et al., 1996), and found that the spell checker's success at providing appropriate suggestions for these errors was modest at

best. For example, MacArthur et al. (1996) tested the success rate of 10 spell checkers and found that on average, the checkers suggested the correct spelling for 53% of all misspellings. However, for the more severe misspellings in the corpora, this percentage dropped to 23%. These percentages were based on the criterion of having success (i.e., the correct suggestion) in the first 10 words listed. For a stricter criterion of success in the very first word in the list, the percentage rates of correction dropped from 53% to 28% for all misspellings, and from 23% to 11% for more severe misspellings.

Similarly, Montgomery et al. (2001) tested the success rate of spell checkers from nine word processing programs using errors from learning disabled students in grades three through eight. Three of the spell checkers were also used in MacArthur et al.'s (1996) study, and two of the spell checkers came from word processing packages used in MacArthur et al.'s study, but Montgomery et al. used a more recent version. Montgomery et al. found that the spell checkers' success rates were more efficient when the errors were phonologically closer and had similar letter strings to the correct spelling. However, the overall success rates were similar to MacArthur et al.'s results. Montgomery et al. found that the spell checkers provided the correct suggestion for 53% of the misspellings and the correct spelling appeared first in the suggestion list for 22% of the misspellings. Thus, taken together, these studies suggest that the spell checker may be a particularly challenging tool for developing spellers to use.

Because the spell checker has limitations, research is needed on how children learn to use the spell checker and how best to teach them to use it. MacArthur et al. (1996) also reported on a second study with participants in addition to their corpus study (i.e., MacArthur et al.'s study had two parts; the first study involved an analysis of

children's errors taken from their writing samples, and in the second study, the authors asked a sample of students to write a story on the computer and in turn, analyzed their errors and success at error correction). In the study with participants, they asked seventh- and eighth-grade students with severe learning disabilities to compose a story on the computer and to proofread the story for spelling errors. They found that when participants used the spell checker, on average, they corrected 37% of the misspellings. In addition, another study found meaningful differences in the ways, Nathan and Zeke, two fourth-grade boys with learning disabilities approached the task of learning to use a spell checker (Dalton, Winbury, & Morocco, 1990). For example, while Nathan quickly mastered the spell checker's operations during his first training session, Zeke required three sessions as well as frequent assistance from the researcher to operate and respond to the spell checker's feedback. This finding suggests that there may be variability in the learning process of students using a spell checker. Some factors that may explain this variability include spelling ability, motivation, self-efficacy, and attitudes toward spelling, writing, and writing with computers. At present, these conjectures are speculative, and research is needed to assess the contribution of each of these factors to successful learning and use of the spell checker. My study may serve as a starting point for addressing children's successful use of the spell checker by providing a description of children's methods of error correction and their use of the spell checker to detect and correct errors.

To my knowledge, only one study has addressed the issue of trying to improve the proofreading techniques of students using a spell checker from either elementary or high school. McNaughton, Hughes, and Ofiesh (1997) gave three high school students with

learning disabilities a specific and detailed five-step proofreading protocol incorporating multiple strategies and the use of the spell checker. Over a period of four months, they found that all three students improved their strategy use and the percentage of spelling errors corrected (percentage increase from baseline to maintenance ranged from 22% to 47%). Because these findings are from a case study, it is not clear that they can be generalized to the high school population of students with learning disabilities, nor to other populations (e.g., elementary school and high school students with different levels of spelling ability).

Summary of what is known and unknown

To summarize, research has shown that children's writing improves with age. The development of literacy skills, such as writing and spelling, requires a possession of linguistic knowledge to nurture skill growth, an understanding of the function and purposes of print, and an appreciation for the need to improve one's work through the revising and editing process in order to achieve clarity of written communication. When put into the context of realizing one's writing goals in the computer environment, research on writing and editing using a word processor and spell checker has shown that these devices have the potential to support children's writing and spelling, but their limitations pose a challenge to developing and novice writers.

The Problem

Rationale for the dissertation

The field of applied developmental psychology seeks not only to describe and explain children's development but also to identify ways to optimize development. In this way, applied developmental psychologists' research programs often consist of a marriage

between basic and applied research questions. For example, within the area of children's spelling development, researchers have tried to describe the developmental characteristics of children's spelling skill (e.g., phonological awareness) (e.g., Treiman, 1993, 2000) and to use these insights to shed light on best instructional practices for nurturing and supporting this development (e.g., explicit phonemic awareness training) (e.g., Byrne & Fielding-Barnsley, 1991). To this end, the dissertation study has both theoretical and practical aims: describing children's use of spelling knowledge in a challenging and interactive environment and using this contextual information to reflect on directions for instructional practices. Below, I have outlined in more detail the theoretical and practical foci of the dissertation study.

Theoretical significance. Developmental psychologists have argued for the need to consider particular behaviours across different contexts and to provide a description of psychological processes across various situations of observation (e.g., Kagan, 2004). In the domain of spelling, a complete model of spelling skill development requires an explanation of how the spelling process interacts with the environment. For example, the dissertation study is situated within one specific environmental context and its design allows for a descriptive analysis of the spelling process within this context. Further, within a specific contextual environment, both global- and domain-specific processes are considered important for producing a complete model of cognitive development (Kail, 2004). For example, within the context of writing using a word processor, global processes such as planning, self-regulation and problem-solving (Burtis et al., 1983; Fitzgerald, 1987; Graham & Harris, 2000) may contribute to task performance. This contribution may take place in conjunction with domain-specific processes (Kail, 2004),

such as topic knowledge (Bereiter & Scardamalia, 1987; Butterfield et al., 1994) and knowledge of orthographic conventions (Cassar & Treiman, 1997; Griffith, 1991; Varnhagen et al., 1999).

In particular, problem-solving is important when applying learned skills because the ability to solve problems by applying domain-specific knowledge is critical to functioning effectively in a variety of contexts (Bransford, Sherwood, Vye, & Rieser, 1986). Price and Driscoll (1997) stated that problem-solving is a process that individuals engage in when three conditions are met: first, there must be a task that requires a solution; second, the problem solver does not, for the moment, know how to reach the solution; and third, there is a perceived need for the solution. Within the context of the dissertation study, the task requiring a solution would be the need to correct an error in spelling. Further, for errors where the problem solver does not know or is unsure of the correct spelling, it might be reasonable to suggest that, for the moment, they do not know how to correct the error. Finally, given the context of writing as a form of communication, it might be suggested that the need for error-free text is present. Thus, in situations where a child may wish to write a word, has attempted to spell the word and created an error, and for the moment, does not know how to correct the error, the task becomes a relevant problem. In such situations, the ability to solve the problem (i.e., correct the error properly) may depend on not only the child's spelling knowledge, but in addition, their ability to problem-solve (e.g., to apply their own knowledge and to use available tools to arrive at a solution).

When children apply their spelling knowledge when first attempting to spell, they tend to use a variety of strategies and over time, the frequency of application of specific

strategies changes (Rittle-Johnson & Siegler, 1999; Varnhagen et al., 1999). That is, their behaviours are strategic in nature because they attempt to solve the problem using multiple or various types of knowledge (e.g., phonological, orthographic) and because they adapt their behaviour in response to the problem (Rittle-Johnson & Siegler, 1999; Varnhagen et al., 1999). Similarly, it could be suggested that children's approach to correcting their spelling in the word-processing environment may involve using a variety of methods to correct misspellings and adapting their behaviour or use of tools in response to the demands of the environment. Thus, the dissertation's theoretical significance falls within the realm of describing children's use of spelling knowledge in a challenging and interactive environment.

Practical significance. Computer use is becoming increasingly common in schools. Among computer activities, word processor use is the most common computer activity (Becker, 2000b) and the most used technology for literacy teaching (Mumtaz & Hammond, 2002). Teachers consider technology to be an important tool for effective literacy instruction (MacArthur, Ferretti, Okolo, & Cavalier, 2001), and there has been an increase in the ways technology has been integrated into school curricula (Anderson-Inman, 1999). For example, computers have been incorporated into spelling instruction by providing students time to engage in spelling exercises on the computer and incorporating programs with individualized instruction into students' lesson plans (Torgeson & Elbourne, 2002; van Daal & Reitsma, 2000). In addition, there is an increase in computer use at home by children (Becker, 2000b).

Skill at writing with word processors is crucially important as the demand for typed text increases in secondary school and beyond. Students may be encumbered by

poor writing skills and limited knowledge about word processors. Academic frustration could result in failure to pursue or complete post-secondary education and a loss of human potential for society (Anderson-Inman, 1999).

When combined with systematic efforts to teach strategies for writing, computers can have a positive impact on both the writing process and the social context of writing in the schools (MacArthur, 1988). However, there is an element of caution put forth concerning the potential hazards of computer-assisted writing, particularly for non-proficient writers (e.g., Pennington, 1993). Thus, research is needed to investigate the potential benefits and pitfalls to introducing computer use in the grade school and junior high school environments. Unfortunately, we have only a moderate amount of knowledge about the effects of word processing on developing writers. This is a particularly important group because these writers are in the process of developing writing and editing habits that they will continue to rely on over the long term.

One aspect of the mechanics of writing, mastery of spelling conventions, can be a difficult task for many children (e.g., Treiman, 1993). In particular, children learning English are likely to encounter spelling problems and difficulties because the English writing system has several complexities (e.g., one-to-many correspondences between phoneme and graphemes, morphological considerations that may override strictly phonological spellings) (Spencer, 2002; Treiman, 1993). Although proper spelling may seem less important than content, it is critical to look at problems in transcription because they directly affect quality of written products (MacArthur, 1999). Spelling errors interfere with the writer's ability to attend to higher order processes, such as reading the text for comprehension (Graham & Harris, 2000; MacArthur, 1999; McCutchen, 1994).

In turn, spelling errors distract readers and affect their judgments about writing quality and writing ability (Figueredo & Varnhagen, 2005; Kreiner, Schnakenberg, Green, Costello, & McClin, 2002; Varnhagen, 2000). Moreover, difficulty with spelling can lead to unfavourable outcomes in writing. For example, poor spellers may purposefully limit their vocabulary usage to words that they are fairly certain they can spell correctly. In addition, poor spellers may find writing becomes an unpleasant chore to be avoided. If spelling problems are ignored, the long-term effect could be detrimental as the stigma of poor spelling can be compromising to achieving one's academic and professional goals (X, 1991). Thus, proofreading written text for spelling errors is a critical activity in the writing process.

Studying the use of literacy skills, such as spelling, in different contexts has important practical implications. Although children typically learn to spell using exercise books, drills, and formal spelling dictation tests, the ways in which they are required to spell outside of the school context are different. It is rare that adults are required to take a spelling dictation test; however, they may need to write in various contexts (on paper, on the computer). Thus, having the ability to apply spelling skills in various contexts is a critical aspect of being a successfully literate person (Lee-Vieira, Mayer, & Cameron, 2006; Treiman, 1997). Research on children's spelling on the computer and use of the spell checker suggests that this medium poses substantial problems for these developing spellers. In keeping with the theoretical and practical significance of this research problem, the theoretical framework for the dissertation will consist of a description of the interaction between student and tool in the computer environment and a cognitive task analysis of the spelling process in the word processor environment.

Theoretical framework for the dissertation

Description of the interaction between student and tool in the computer environment. In order to orient the discussion of theoretical issues related to the spelling process in the word processor environment, I will first provide a description of the student in the computer environment. The physical environment consists of a student sitting at a computer (e.g., in a computer lab). The writing tools consist of using a combination of keyboard and mouse while watching a monitor screen. The transcription skills needed to support the writing task consist of a combination of spelling and typing (touch typing or "hunt and peck") skills. The potential resources available to support the spelling process consist of the writer him/herself, dictionary (paperback or online), and the spell checker.[2] When considering the interaction between the student and tool in the computer environment, it's useful to distinguish situations in which the student "knows the spelling" of a word (i.e., retrieving the spelling of *cat*) as compared to situations in which the student does not. Regarding this latter situation, rather than conceptualizing spelling as an invariant skill (i.e., you know the spelling or you don't), it may be more suitable to conceptualize spelling as a *problem-solving process that relies on resources such as learner's knowledge and tool use* (e.g., Liu & Bera, 2005) because it encapsulates the person-environment interaction (i.e., success at spelling may in part depend on the level of skill/knowledge the person can bring to the task as well as their familiarity and ability to negotiate the environmental resources).

Further, when considering the spell checker as a potentially helpful tool, it may be particularly useful to consider how the spell checker may support the student in achieving success at error correction. In particular, the spell checker may be able to detect errors

that the student would not have been able to detect alone and it may be able to aid in the correction process by offering suggestions for error correction that the student may not have been able to produce alone. In this way, the spell checker may act as a scaffolding agent (Vygotsky, 1978) by allowing the student to accomplish a task within his/her zone of proximal development (Vygotsky, 1978). The spell checker supports or scaffolds the proofreading task, and in this way the student is able to acquire knowledge and complete tasks while interacting with a computer tool that, within the zone of proximal development, mimics a more competent other (Vygotsky, 1978).

Cognitive task analysis of the spelling process when using a word processor. Having drawn a theoretical comparison between paper and computer environments and conceptualized the spelling process as a problem-solving process, I will now discuss some theoretical issues related to the spelling task when using a word processor in the computer environment. The goal of *cognitive task analysis* is "to identify the cognitive processes and knowledge required to accomplish basic academic tasks" (Mayer, 2004; p. 718). The main cognitive tasks required to ensure correct spelling when using a word processor are attempting to spell a word, detecting any spelling errors, and correcting any spelling errors. Attempting to spell a word typically involves linguistic knowledge and strategies (see review of literature on children's spelling skill) regardless of environment. Detecting a spelling error involves word recognition in both the paper and computer context, but this process may also be aided by the spell checker in the computer environment (i.e., spell checker flags the error). Finally, correcting a spelling error involves linguistic knowledge and strategies regardless of environment, but this process may also be aided by the spell checker (i.e., spell checker offers correct suggestion). It is

important to consider the writer's resources (e.g., linguistic knowledge, strategies) and external environmental resources (e.g., spell checker, dictionary) as being interactive in nature (e.g., writer uses linguistic knowledge to evaluate spell checker's suggestions). Thus, the writer's cognition is always engaged as manager and user of multiple resources.

Statement of the problem to be investigated

One expectation of training children to become literate members of society is that they will be able to apply their literacy skills to a wide variety of situations and contexts. This expectation requires children and adults to transfer their knowledge to different contexts within a domain. In particular, they may need to apply their spelling skills when writing in different environments (e.g., on paper, with a computer). What is not clear is whether application of spelling skills in different environments requires or involves the same set of problem-solving processes and whether the changes from one environmental context to the next in any way changes the nature of the spelling process. In this dissertation, *the problem needing investigation* is to provide a description and analysis of children's spelling process in the computer environment and to specifically focus on the use of the spell checker in this new environment.

Original Contribution of the Dissertation

There is a dearth of research on describing children's process of using spell checkers during the writing or revising process. This research is needed to identify ways in which children use checkers (i.e., procedural pattern). Specifically, students need to learn strategies to tap into the spell checker's potential usefulness while dealing with its limitations. It is the responsibility of the writer to determine both if a flagged word truly is an error and if so, how it should be corrected. Thus, proper use of the spell checker as a

supportive tool is a skill in itself (Connors & Lunsford, 1992). Conversely, spell checkers need to be made more user-appropriate for children. A description of children's errors and their use of the spell checker to correct those errors may provide direction for improving the design of spell checkers.

Such a research program has the potential to contribute to the knowledge of spelling and writing development in a computer environment and may be applicable in helping multiple populations who encounter this technology (e.g., students at various school levels, students with learning disabilities, students with poor spelling skill). While studies such as MacArthur et al. (1996) and Montgomery et al. (2001) have established that the spell checker has substantial difficulty suggesting appropriate corrections for children's spelling errors, these studies have limited external validity. Although these studies drew on naturalistic data (i.e., errors comprising the corpora were taken directly from children's writing samples), their results may not be an accurate reflection of how helpful the spell checker may be in situ. That is, the spell checkers' success rate in these studies may not be realized in practice. Specifically, the assumption is that as long as the spell checker offers the correct suggestion, children will choose that particular suggestion. There are two potential cases where difficulties may arise that would discount this assumption.

In the first case, if the correct suggestion is the only suggestion offered, children need to recognize that it is indeed the appropriate spelling (as opposed to choosing the option to ignore or correcting the error in a different way). In the second case, if the correct suggestion is among a list of suggestions offered, children need to deduce which

of the suggestions has the appropriate spelling. For developing spellers, these tasks may be problematic.

Alternatively, the spell checker's success rate may be a misleading underestimation of children's overall spelling success. When the spell checker does not offer the correct suggestion, it is not necessarily appropriate to assume that the misspelling will not be properly corrected because it does not allow for situations in which children's problem-solving process leads to the correct answer (e.g., using their linguistic knowledge or other resources, such as a dictionary, to alter the letter sequence until the spell checker's list of suggestions includes the correct spelling). In short, assumptions made about children's success at spelling inferred from the spell checker's success rate does not acknowledge the active role of child as problem-solver and the person-environment interaction. Thus, research on the process by which children operate and make use of the spell checker may provide insight into both the benefits and drawbacks of spell checker use for novice writers. The dissertation study provides an *original contribution* to the research by providing a description and analysis of the process by which children in grades four and six use the spell checker during composition to proofread their written text for spelling errors.

Pilot Study with Adults

To help in the construction of thesis design and methodology, I conducted an exploratory pilot study where I investigated adults' use of the spell checker during the writing process. I wanted to investigate whether variables important to the composition task could be operationalized and measured. Undergraduate students enrolled in an introductory psychology course were asked to compose a short essay during a period of

20 minutes using a word processor. The essay topic was recovered memories and participants were instructed to focus on both quality of content and correctness of surface features. Participants had access to the spell checker and an online dictionary. After the composition task, participants were given a standardized spelling test and they were asked to complete a questionnaire on their educational background and language skills.

Results showed that participants made errors when writing words including misspellings and other errors in spacing, punctuation, and capitalization. Further, participants used methods of error correction such as correction themselves and use of the spell checker. In addition, it was possible to define correction time as the time from which an attempt to correct began to the time to which the attempt ended. Thus, the data from the pilot study indicated that variables important to the composition task could be operationalized and measured.

Research Design

General Description of Research Design

The aim of the dissertation study was to provide descriptions of children's use of the spell checker during composition. Because there was not enough existing research to provide adequate direction for experimental investigation, nor to justify the cost of designing a longitudinal study, I chose to conduct a study with a non-experimental and cross-sectional design. A weakness of cross-sectional studies is that age effects are confounded with cohort effects. Although, it was impossible to separate these effects, I asked participants to fill out a questionnaire on their experiences and use of the word processor. This information was useful in describing similarities and/or differences in computer experience among cohorts.

To capture developmental differences in performance, I chose to sample students from grades four and six. Research has demonstrated that great progress in development of writing, (e.g., Bereiter & Scardamalia, 1987), transcription (e.g., Graham & Harris, 2000), and spelling (e.g., Cassar & Treiman, 1997; Evans & Smith, 1989) skills occurs during the upper elementary school years. Further, transcription plays an important role in the writing process during this period (Berninger & Swanson, 1994). Thus, it was suitable to document changes in spell checker use during this range because it was related to and supported by the aforementioned skills.

Research Question and Predictions

The *research question* posed in this study was: when do children choose to use the spell checker during the composing process and how successful are they at correcting errors when using the spell checker?

My study had three main predictions concerning children's use of the spell checker:

I. Children will use a variety of methods to correct errors. These methods include correcting the error themselves (e.g., backspace and correct), using the spell checker (e.g., selecting an option from the list of suggestions), and a combination of correcting themselves and using the spell checker.

II. Children will choose to correct themselves more often than using the spell checker for errors that are not misspellings, but will use the spell checker more often than correcting themselves for misspellings.

III. Both spelling ability and ability to use the spell checker properly will increase across grade level.

Because this study was exploratory and descriptive in nature, the results section of the study includes both a descriptive analysis of the data and an analysis of the data regarding the above predictions.

Rationale for Measures in Study

Rationale for composition task. A composition task was used because writing a story was a familiar task for school-age children and writing researchers commonly use this type of composition task to solicit writing samples from children (e.g., Berninger & Swanson, 1994; Rentel & King, 1983). Further, the topic "A Special Day" was purposefully vague to allow participants sufficient breadth to draw on their experiences (e.g., birthdays, vacations). In addition, children enjoyed writing about this topic and 20 minutes was a sufficient amount of time to allow children to write a story of reasonable length and to capture their use of the spell checker. Because I wished to describe the ways in which children used word processors that they could potentially continue to use throughout their lives, I chose not to use a word processing program specifically designed for children. Instead, the story was written using a laptop computer with Microsoft Word (XPpro version). Microsoft Word is one of the most common word processing programs available to computer users, and it is quite likely the most widely used word processing program in the world (McGee & Ericsson, 2002).

Rationale for typing and spelling tests. It was important to have a measure of typing ability because transcription is an integral part of the writing process, and typing ability could affect several aspects of the composition task (e.g., story length, number of errors committed). Thus, a typing test was used as a measure of typing ability so that I could investigate how typing ability related to variables in the composition task. It was

important to have a measure of spelling ability because spelling is a critical component of the transcription process, and spelling ability could affect several aspects of the composition task (e.g., number of spelling errors committed, method of error correction).

Rationale for questionnaire. The questionnaire was important in order to have information on computer, word processor, and spell checker use in the school and at home. In particular, the questionnaire was designed with three purposes in mind. First, similar studies have found that items in self-report questionnaires are related to study variables (e.g., Klassen, 2002; Shaver, 1990). For example, Shaver (1990) found that attitude toward writing was related to writing quality. Thus, in line with the goals of exploring and describing children's use of the spell checker, it was important to have reports on participants' views and attitudes about the spell checker because it could provide insight and be related to variables in my study. Second, I wished to demonstrate the relation between my study's measures and their natural occurrence. Thus, relations between self-report items and task performance could provide support for external validity. Third, I wished to elicit specific and detailed information on the ways in which children use spell checkers, their feelings toward spell checkers, and how the spell checker is related to the larger context of spelling and writing development. This information could provide a more complete picture of the background and real-life context of spell checker use. In order to make the questionnaires age-appropriate, the fourth-grade questionnaire was slightly shorter than the sixth-grade questionnaire.

Method

Participants

Twenty-five male and 27 female fourth-grade students ($n = 52$) and 16 male and 21 female sixth-grade students ($n = 37$) enrolled in three elementary schools in Leduc, Alberta participated in this study.[3] The mean age of the fourth-grade participants was 9 years 10 months ($SD = 0$ years 5 months, Range = 9 years, 1 month to 10 years, 10 months) and the mean age of the sixth-grade participants was 11 years 11 months ($SD = 0$ years 7 months, Range = 10 years, 8 months to 14 years, 3 months). The first language of all participants was English. Students did not need to have touch typing skill in order to participate.[4] Table 1 provides demographic information on the fourth-grade and sixth-grade groups and Table 2 presents the standard WRAT3 spelling scores and adjusted word-per-minute typing scores for each grade level.[5] On average, sixth-graders had better typing scores (t (87) = 7.17, $p < .01$) than fourth-graders did.

Table 1

Fourth- and sixth-grade participants' responses to questionnaire items

	% Response	
	Fourth-grade participants	Sixth-grade participants
Computer in the home	98	97
Computer use		
Homework/school assignments	46	87
E-mail	56	73
Chat/discussion rooms	24	65
Internet surfing	58	81

Downloading music	38	70
Computer games	82	84
Writing using word processor	58	65
Webpage design	16	27
Good at spelling words	55	54
Like to write stories	63	59
Probably write with computer in adult job	44	43
Comfortable using word processor including its tools	N/A	74
Writing with computer more fun than on paper	N/A	87
Computer makes writing more difficult	N/A	9
If typed faster, then would like writing with computer more	N/A	74
Resources used for checking spelling		
Teacher	60	73
Classmate	34	57
Family member	46	57
Dictionary	32	43

Spell checker	54	87
Sound out and re-write	52	43
Things I like about word processor		
Can write faster	N/A	61
Can delete words easily	N/A	65
Can cut and paste	N/A	61
Has a spell checker	N/A	83
Has a grammar checker	N/A	74
Writing looks neat and tidy	N/A	74
Other people can see screen	N/A	35
Can work with other students at computer	N/A	26
Can print out my work	N/A	52
Frustrating things about word processor		
Hard to type	N/A	13
Not sure how to use tools	N/A	30
Confused by all the options	N/A	35
Press the wrong button and can't fix problem	N/A	61
Can't share my work easily	N/A	22
Forget to save my work	N/A	44

Note. The percent response for the items with a Likert scale was calculated based on the proportion of participants that indicated "4" or "5" on the scale (see Appendix B and C). N/A = not applicable. These items were not on the fourth-grade questionnaire (see Appendix B).

Table 2

Mean standardized scores (and standard deviations) for the WRAT spelling subtest and adjusted wpm scores for the typing test for each grade

Grade	WRAT3 (standardized)	Adjusted wpm
4	106 (11)	7 (3)
6	106 (15)	13 (6)

Teacher questionnaire. Six teachers completed the questionnaire on teacher preferences. Three teachers taught fourth-graders and three teachers taught sixth-graders. The teachers reported that they had been teaching for an average of 15 years (*SD* = 11 years, min = 1 year, max = 28 years). Table 3 shows the teachers' responses to questionnaire items. All teachers reported that the spell checker was preferred as a resource students should use to proofread text for spelling errors. In addition, most teachers reported that asking others (classmate, teacher, family member) was a preferred resource. All teachers reported encouraging the use of the spell checker to proofread their writing for spelling errors and no teacher reported that they disallow the use of the spell checker. There were no differences in responses between the fourth- and sixth-grade teachers.

Table 3

Teachers' responses to questionnaire items

	% Response
Resources students should use	
Ask classmate	83
Ask teacher	83
Ask family member	83
Dictionary	67
Spell checker	100
Self (sound out and re-write)	67
Encourage use of spell checker	100
Disallow use of spell checker	0

Measures

Four tasks were administered to participants: (a) composition task, (b) typing test, (c) spelling test, and (d) participant questionnaire. In addition, teachers were also asked to fill out a questionnaire on their beliefs and practices.

Composition task. For the composition task, participants had a 20-minute period to write a story entitled "A Special Day" using a word processor. Table 4 shows the settings for the checkers in Microsoft Word. To document the procedural patterns of spell checker use and to aid in the classification of methods used to correct errors, the computer was equipped with a microphone and Camtasia Studio software (TechSmith Corporation, 1990-2002). This software package provided an audio-visual record of the

composition task in real time.[6] To aid with error correction, the spell checker was turned on and a paperback dictionary was provided.[7] The participant was told that he/she had access to these tools, if he/she wished to use them.

Table 4

Settings for Checkers in Microsoft Word (XPpro Version)

Options	Option turned on
Spell checker	
Check spelling as you type	Yes
Hide spelling errors in this document	No
Always suggest corrections	Yes
Suggest from main dictionary only	Yes
Ignore words in UPPERCASE	Yes
Ignore words with numbers	Yes
Ignore Internet and file addresses	Yes
Auto-correct	No
Grammar	
Check grammar as you type	Yes
Hide grammatical errors in this document	No
Check grammar with spelling	Yes
Show readability statistics	No
Other Options	
Custom dictionary	English – Canada
Writing Style	Standard

Typing test. The second task I administered to participants was a typing test. The typing test was designed using Authorware software (Macromedia, Inc., 2001) and administered on the computer. The paragraph for typing was taken from a typing exercise on the website Nimble Fingers (www.nimblefingers.com) (see Appendix A). The typing test recorded the total time, total number of words, and calculated the words typed per minute.

Spelling test. The third task I administered to participants was a spelling test. The spelling test I used was the spelling subtest of the Wide Range Achievement Test 3 (WRAT 3; Wilkinson, 1993).

Participant questionnaire. The fourth and last task I administered to participants was a questionnaire (see Appendices B and C for fourth- and sixth-grade participants, respectively). In order to make the questionnaires age-appropriate, the fourth-grade questionnaire was slightly shorter than the sixth-grade questionnaire. The questionnaires were created from various sources. Some items were based on questionnaire items used in previous research (Becker, 2000a, 2000b; Figueredo & Varnhagen, 2004; Klassen, 2002; Shaver, 1990). Other items were created for the purposes of this study. Although, self-report data has the limitation and disadvantage of being potentially biased, children at the grade range for my study tend to be more realistic about not overestimating their abilities than younger children tend to be (Klassen, 2002).

Teacher questionnaire. In addition to the participant tasks, teachers were asked to fill out a questionnaire on computer use in the classroom and about their philosophies and beliefs about word processor and spell checker use (see Appendix D). Previous research has shown that there can be a wide range of variability in teachers' beliefs and values

concerning computer use (e.g., Cochran-Smith, 1991), and thus it was advantageous to have information on teacher and classroom background as related to the purposes of my study.

Materials

For the composition task, I used a laptop computer with Microsoft Word (XPpro version). This word processing package had a built-in spell checker and grammar checker. Most options were turned on for the checkers (see Table 4). Further, participants had access to a paperback dictionary. Camtasia Studio software (TechSmith Corporation, 1990-2002) and a microphone were used to record the writing process in order to have an audio-visual record of their writing in real time. For the spelling test, the spelling component of the Wide Range Achievement Test 3 (WRAT 3; Wilkinson, 1993) was administered. Items were orally dictated by the experimenter and participants were asked to write each item using a paper and pencil. For the typing test, participants were asked to type the paragraph on the laptop computer.

Procedure

During a period of approximately 30 minutes, participants were given the composition task and the typing test in an individual session outside of the classroom. For the composition task, participants were asked to write a short story entitled "A Special Day" using the word processor. They were told they had access to the spelling and grammar checkers and to a paperback dictionary. They were asked to write as well as they could and to make sure that they corrected any errors in their story. After the composition task, participants were administered the typing test. Participants were asked

to type one paragraph exactly as shown on the computer as quickly as possible without sacrificing accuracy.

After all individual sessions for participants from a given classroom had been completed, participants were administered the spelling test and the questionnaire in one group session. For the spelling test, the experimenter read a list of words aloud to participants and asked them to write each word on lined paper. For each word, the experimenter read the word, followed by a phrase containing the word, and then read the word again. For the questionnaire, participants were told to complete the questionnaire as accurately as possible. In addition, they were told there were no "right or wrong" answers and that they could skip any questions they did not want to answer. The group session took approximately 30 minutes.

Results

The Results section is broadly divided into six sections: (a) descriptive analyses of the composition task, (b) analyses related to Prediction I, (c) analyses related to Prediction II, (d) analyses related to Prediction III, (e) exploratory analyses between composition task variables for misspellings, and (f) relational analyses between the composition task, transcription skills, and the student questionnaire, and relational analyses between the student questionnaire items. Exploratory analyses between the composition task variables for misspellings may indicate how students' correction of misspellings relates to error severity and relational analyses between the composition task, transcription skills, and the student questionnaire may indicate whether students' transcription skills and their reports of spell checker use are related to composition task performance.

Descriptive Analyses of the Composition Task

The variables that provide a descriptive analysis of the composition task include the story length, the number and type of errors committed, the correction time of the errors, and the number of errors corrected properly. The *story length* of the composition consisted of the number of words contained in the composition at the end of the task time. The mean story length was 78 words (*SD* = 52, Range = 19 to 327) and 128 words (*SD* = 67, Range = 50 to 308) for fourth- and sixth-grade participants, respectively. After entering typing skill as a covariate with grade level as a between-subjects factor, there was no significant difference between story lengths for the grade groups.

A descriptive analysis of the errors committed by fourth- and sixth-grade participants is presented in Table 5. Errors consisted of errors that were or were not flagged by the spell checker. Errors that were flagged by the spell checker consisted of *misspellings* and *other errors* (i.e., errors in capitalization, spacing, and punctuation). Errors that were not flagged by the spell checker consisted of cases in which the spell checker did not recognize the letter sequence as a misspelling (e.g., homophone *(beat-beet)* and real-word errors *(fist-first)*). For the purposes of the dissertation, because I wanted to focus on misspellings as opposed to grammatical errors which may also be flagged by the spell checker, the analyses that follow involve *error type* split into two categories: *misspellings* and *other errors* (where other errors consist of errors in capitalization (*santa* for *Santa*), spacing (*big.We* for *big. We*), and punctuation (*did'nt* for *didn't*)). Table 5 also shows the spell checker's number of *false positives*, or words that were spelled correctly, but erroneously flagged by the spell checker (e.g., person's name, American spelling). Fourth-grade participants ignored 84% and changed 16% of false

positives and sixth-grade participants ignored 72% and changed 28% of false positives. Most of the changes to false positives involved choosing the Canadian spelling from the spell checker's list (e.g., switching from *favorite* to *favourite* or *gray* to *grey*).

In addition to a tally of the types of errors, Table 6 shows the mean number of total errors, misspellings, and other errors committed by fourth- and sixth-grade participants. Two fourth-grade participants and one sixth-grade participant did not commit any errors. On average, fourth-grade participants committed six errors and sixth-grade participants committed seven errors during the composition task. After entering typing skill as a covariate with grade level as a between-subjects factor, the sixth-grade group committed significantly more errors than the fourth-grade group (F (1, 86) = 4.80, $p < .05$).

The *correction time* of an error was defined as the time from when an attempt to correct began to when the attempt ended. For all errors where an attempt to correct was made, the mean correction time was 15 seconds (SD = 36 seconds, Range = 1 to 287 seconds) and 9 seconds (SD = 21 seconds, Range = 1 to 167 seconds) for fourth- and sixth-grade participants, respectively. On average, fourth-grade participants took longer to correct errors than sixth-grade participants did (t (494) = 2.29, $p < .05$).

If the method of correction resulted in *correcting the error properly*, then these errors were coded as such. The exception to this rule was when participants chose to correct the error by switching to a different word.[8] If no attempt to correct was made

Table 5

Descriptive statistics for errors produced during composition task by fourth- and sixth-grade participants

	Fourth-grade participants		Sixth-grade participants	
	#	%	#	%
Errors flagged by spell checker				
Misspellings	160	53	138	56
Other – Capitalization errors	38	13	50	20
Other – Spacing errors	90	30	55	22
Other – Punctuation errors	13	4	4	2
Total	301	100	247	100
Errors not flagged by spell checker				
Homophone errors	19	38	9	17
Real-word errors	31	62	44	83
Total	50	100	53	100
False positives				
Name	24	77	24	62
American spelling	3	10	9	23
Other	4	13	6	15
Total	31	100	39	100

Table 6

Descriptive statistics for errors produced during the composition task by fourth- and sixth-grade participants

	Fourth-grade participants	Sixth-grade participants
	M (*SD, Range*)	M (*SD, Range*)
Number of total errors	6 (4, 0 to 15)	7 (5, 0 to 21)
Number of misspellings	3 (3, 0 to 11)	4 (3, 0 to 15)
Number of other errors	3 (3, 0 to 15)	3 (3, 0 to 11)

Table 7

Mean (standard deviation in parentheses) percent of errors corrected properly for fourth- and sixth-grade participants

	Fourth-grade participants	Sixth-grade participants
	Mean percent of errors corrected properly	Mean percent of errors corrected properly
Error type		
Misspellings	80 (31)	75 (28)
Other	82 (32)	82 (33)

(e.g., participant did not attempt to correct the error *niether* (neither)) or if the method of correction did not result in a proper correction (e.g., participant backspaced and changed *niether* to *neithier*) or if the method consisted of switching the word (e.g., participant deleted *niether* and wrote *any of them*), then these errors were coded as not corrected

properly. The percentage of errors corrected properly was 81% and 76% for fourth- and sixth-grade participants, respectively.

As Table 7 shows, there was no significant relation between error type and percent of errors corrected properly for fourth- and sixth-grade participants.[9] Thus, for both grade groups, there was no difference in the percent of misspellings and the percent of other errors corrected properly.

Analyses Related to Prediction I

My first main prediction concerning children's use of the spell checker was:

I. Children will use a variety of methods to correct errors. These methods include correcting the error themselves (e.g., backspace and correct), using the spell checker (e.g., selecting an option from the list of suggestions), and a combination of correcting themselves and using the spell checker.

To address this prediction, I conducted a descriptive analysis of the frequencies of use of different methods of correction. For the errors that were flagged by the spell checker, a descriptive analysis of the methods of error correction used by fourth- and sixth-grade participants is presented in Table 8. Note that for all of the errors not flagged by the spell checker (i.e., homophone and real-word errors), participants did not attempt to correct these errors and thus Table 8 does not include these errors. As shown in Table 8, the number of errors for which participants attempted to correct the error by using a dictionary or by switching to a different word is quite small, and so for subsequent analyses, *method of correction* consists of three categories: spell checker, self, and combination of methods.

Table 8

Descriptive statistics for methods of error correction during composition task by fourth- and sixth-grade participants

	Fourth-grade participants		Sixth-grade participants	
	#	%	#	%
Method of error correction				
Spell checker	112	37	67	27
Self	124	41	123	50
Dictionary	0	0	3	1
Switched to a different word	4	1	3	1
Combination of methods	41	14	19	8
No correction attempted	20	7	32	13
Total	301	100	247	100

As stated in Prediction I, participants used a variety of methods to correct errors. Table 9 shows the mean rates of the three most frequent methods for both grade groups: using the spell checker, correcting themselves, and using a combination of methods. For example, to correct an error themselves, a participant might make an error in spacing such as *playfu l* (*playful*), and then backspace to the error and delete the space between the letters *u* and *l*. To use the spell checker, a participant might right-click on the error *playfu l* in order to view the menu of suggestions, and then select the suggestion *playful*. To use a combination of methods, consider the misspelling *probly* (*probably*).

Table 9

Rates of using methods of correction for fourth- and sixth-grade participants

	Fourth-grade participants	Sixth-grade participants
	M % (*SD* %)	M % (*SD* %)
Rates of use		
Spell checker	36 (33)	27 (30)
Correcting themselves	47 (35)	61 (33)
Combination of methods	14 (19)	8 (15)

The participant first viewed the spell checker's list of suggestions and did not find the word *probably* present in the list. Then the participant backspaced and changed *probly* to *probobly*. Then the participant viewed the spell checker's list again and this time selected the word *probably* from the list. As this example illustrates, using a combination of correcting themselves and using the spell checker the participant manipulated the letter sequence of the error (e.g., changing a section of the sequence that was thought to be incorrect) and then checking the spell checker's list of suggestions. Table 10 provides some more examples of the kinds of errors participant made, the methods they used to correct the errors and the correction time. Although correction time and method of correction varied, participants were mostly successful at correcting errors. Further, when participants encountered difficulty correcting an error properly, they sometimes switched to a different word that conveyed a similar meaning (e.g., switching from *my special day* to *my best day ever*).

Table 10

Examples of different types of errors produced during composition task

Type of errors	Example	Method of correction	Correction time (seconds)	Corrected properly
Misspelling	*esspesholy* (especially)	Spell checker	3	Yes
Misspelling	*probobly* (probably)	Combination of spell checker and correct themselves	48	Yes
Misspelling	*doallers* (dollars)	Combination of spell checker and correct themselves	10	Yes
Misspelling	*spicel* (special)	Combination of spell checker, dictionary, and correct themselves	65	No – switched to a different word (*best*)

Other – Capitalization errors	*disney* (Disney)	Correct themselves	4	Yes
Other – Spacing errors	*days.In* (days. In)	Correct themselves	7	Yes
Other – Punctuation errors	*did'nt* (didn't)	Spell checker	3	Yes

Analyses Related to Prediction II

My second main prediction concerning children's use of the spell checker was:

II. Children will choose to correct themselves more often than using the spell checker for errors that are not misspellings, but will use the spell checker more often than correcting themselves for misspellings.

To address this prediction, I conducted analyses to investigate differences in frequency of use of methods of correction for misspellings and other errors with grade as a between-subjects variable. Table 11 shows the relation between error type and method of correction for fourth- and sixth-grade participants. There was an interaction between method and error type (F (2, 126) = 19.32, $p < .01$).[10] To decompose the interaction between method and error type, I conducted post-hoc comparisons between methods at each level of error type (i.e., for misspellings and for other errors). Because there was no effect of grade level or interactions of variables with grade level, I collapsed across grade when conducting these analyses. Tukey's post-hoc comparisons between methods for the misspellings revealed that the mean differences between checker and self and checker and combination of methods were significant, HSD = 0.69, $p < .05$. To correct

Table 11

Mean number (and standard deviation) of errors using different methods of correction for fourth- and sixth-grade participants

	Fourth-grade participants		Sixth-grade participants	
	Error type		Error type	
	Misspellings	Other	Misspellings	Other
	M *(SD)*	M *(SD)*	M *(SD)*	M *(SD)*
Method of error correction				
Spell checker	1.9 (2.0)	0.9 (1.1)	1.8 (2.8)	0.7 (1.7)
Self	0.7 (0.9)	2.0 (2.4)	1.8 (1.5)	2.5 (2.2)
Combination of methods	0.8 (1.1)	0.1 (0.3)	0.7 (0.9)	0.0 (0.2)

misspellings, participants tended to use the spell checker more often than correcting themselves and more often than using a combination of methods.

Tukey's post-hoc comparisons between methods for the other errors revealed that all mean differences were significant, HSD = 0.69, $p < .05$. To correct other errors, participants tended to correct themselves more often than the spell checker and they used the spell checker more often than using a combination of methods. Thus, as stated in Prediction II, participants corrected errors themselves more often than using the spell checker for errors that were not misspellings (i.e., other errors), but they used the spell checker more often than correcting themselves for misspellings.

Analyses Related to Prediction III

My third main prediction concerning children's use of the spell checker was:

III. Both spelling ability and ability to use the spell checker properly will increase across grade level.

To address this prediction, I conducted analyses looking at differences across grade groups in spelling ability and success rates of using the spell checker. *Spelling ability* was operationalized as performance on a spelling test. Sixth-grade participants' raw spelling scores on the spelling test were significantly higher than fourth-grade participants' scores. Thus, as stated in prediction III, spelling ability increased across grade level.

Ability to use the spell checker properly was operationalized as the success rate of using the spell checker. A participant's success rate of using the spell checker was defined as: (the number of errors corrected properly using the spell checker / number of errors attempted to correct using spell checker) x 100%. Table 12 shows the mean success rates of using the spell checker, correcting themselves, and using a combination of methods for both grade groups.[11] Both fourth- and sixth-grade groups' mean success rates of using the spell checker were equally high (i.e., both groups had an 86% mean success rate of using the spell checker to correct errors properly). Thus, by contrast to what was stated in Prediction III, ability to use the spell checker properly did not increase across grade level. In fact, of the participants who used the spell checker, the majority in both grades had 100% success rates. Specifically, 26 out of 34 fourth-grade participants (77%) and 15 out of 23 sixth-grade participants (65%) who used the spell checker had 100% success rates.

To provide greater insight into participants' high success rates of using the spell checker and the usefulness of the spell checker as a tool for aiding in error correction, I conducted two more analyses.[12]

Table 12

Success rates of using methods of correction for fourth- and sixth-grade participants

	Fourth-grade participants	Sixth-grade participants
	M % (*SD* %)	M % (*SD* %)
Success Rates		
Spell checker	86 (30)	86 (26)
Correcting themselves	94 (16)	96 (12)
Combination of methods	72 (44)	100 (0)

The first analysis was conducted to determine whether success at using the spell checker and correcting errors properly was specifically related to the presence of the correct word on the spell checker's suggestion list. Specifically, I compared the occurrence of the correct suggestion on the spell checker's list for the instances when participants corrected or did not correct the errors properly. There was a main effect of percent corrected properly ($F(1, 20) = 27.81, p < .01$).[13] The correct word was on the spell checker's list for more of the errors corrected properly (means of 87% and 99% of errors corrected properly for fourth- and sixth-grade groups, respectively) than for the errors not corrected properly (means of 21% and 60% of errors not corrected properly for fourth- and sixth-grade participants respectively). Thus, the correct word was on the spell checker's list for the majority of instances when participants were successful at using the spell checker. There was no effect of grade level for this analysis.

The second analysis was conducted to determine the location of the correct word on the spell checker's list (e.g., first position, second position) and whether success at

using the spell checker depended on the location of the correct word in the list. Table 13 shows the frequencies of the correct word's position on the spell checker's suggestion list. For errors made by fourth-grade participants, the frequency of the correct word being in the first position in the list, below the first position, or not on the list was 55%, 22%, and 23%, respectively. For errors made by sixth-grade participants, the frequency of the correct word being in the first position in the list, below the first position, or not on the list was 67%, 11%, and 22%, respectively. Thus, for both grade groups, the majority of the correct words were in the first position on the spell checker's list.

Further, for both grade groups, when participants made a selection from the spell checker's list they mostly chose the correct word; for the fourth-grade group, 95% (122 out of 128 instances) of the selections consisted of choosing the correct word and for the sixth-grade group, 96% (65 out of 68 instances) of the selections consisted of choosing the correct word. That is, regardless of position of the correct word on the spell checker's list, participants were mostly successful at choosing that word. Thus, success at using the spell checker did not depend on the location of the correct word in the list.

In addition, for the small number of occurrences where participants did not select the correct word in the spell checker's list, the correct word was in various positions on the list. For the fourth-grade group, there were 6 instances where the correct word was not selected (for three instances the correct word was in the first position, for 2 instances it was in the fourth position, and for 1 instance it was in the fifth position).

Table 13

Frequencies of correct word's position on spell checker's suggestion list for errors attempted to correct using spell checker by fourth- and sixth-grade participants

	Fourth-grade participants		Sixth-grade participants	
	#	%	#	%
Position of correct word on spell checker's suggestion list				
First position	92	55	58	67
Second position	19	12	8	9
Third position	2	1	2	2
Fourth position	4	2	0	0
Fifth position	8	5	0	0
Sixth position	2	1	0	0
Seventh position	1	1	0	0
Not on list	38	23	19	22
Total	166	100	87	100

Note. For some of the errors participants may have viewed the spell checker's list on two or more separate occasions during the correction process (e.g., viewed the list and the correct word was not on the list, then attempted to correct the error themselves, then viewed the list a second time and the correct word was now in the second position on the list).

For the sixth-grade group, there were 3 instances where the correct word was not selected (one instance in each of the first, second, and third positions). Thus, failure to select the correct word did not seem to co-vary with a specific position on the list.

Summary of Results pertaining to Predictions

Participants from both grades made a variety of errors, such as misspellings and other errors (e.g., capitalization, spacing, punctuation). Participants from both grades used a variety of methods to correct errors, including correcting errors themselves, using the spell checker, and using a combination of methods. Participants rarely used the dictionary to correct errors.

Participants' use of methods of correction varied with the type of error being corrected, but there was no effect of grade level for these analyses. Participants from both grades tended to use the spell checker most often to correct misspellings and to correct themselves most often to correct the other errors.

As expected, spelling ability increased across grade level. However, in contrast to what was predicted, ability to use the spell checker properly did not increase across grade level. Both fourth- and sixth-grade groups' mean success rates of using the spell checker were equally high. Further analyses were conducted to investigate the importance of the presence and location of the correct word on the spell checker's list. The correct word was on the spell checker's list for the majority of instances when participants were successful at using the spell checker. Further, regardless of its position on the spell checker's list, both grade groups were mostly successful at choosing the correct word.

Exploratory analyses between Composition Task variables for Misspellings

To capture the severity of the misspellings, I used two measures: bigram ratios and phonetic match ratings. Bigram ratios measured the proportion of correct letter sequences, that is the number of correctly sequenced pairs of letters in a misspelling divided by the score for the correct spelling (MacArthur et al., 1996; Montgomery et al. 2001). For example, consider the misspelling *exsited* (excited). The word *excited* has eight letter sequences (i.e., start-e, e-x, x-c, c-i, i-t, t-e, e-d, d-end) and the misspelling *exsited* has six correctly sequenced pairs (i.e., start-e, e-x, i-t, t-e, e-d, d-end). Therefore, the misspelling *exsited* would have a bigram ratio of 0.75 (i.e., 6/8). The mean bigram ratio for misspellings was 0.70 (*SD* = 0.17, Range = 0.87) and 0.68 (*SD* = 0.18, Range = 1.00) for fourth- and sixth-grade participants, respectively.

Phonetic match ratings consisted of raters' judgments of how close a phonetic match existed between the correct spelling and the misspelling (MacArthur et al., 1996). Misspellings were given a score of 0 or 1, indicating whether the misspelling was correct phonetically (i.e., all phonemes in the correct word were represented in the correct order).[14] For example, the misspelling *exsited* (excited) would be given a score of 1 because all phonemes are represented and the misspelling *eary* (early) would be given a score of 0 because all phonemes are not represented. A second rater scored 20% of the misspellings and a high degree of inter-rater reliability was obtained (Cohen's $\kappa = 0.96$).

For fourth-grade participants, the percentage of misspellings with either a perfect phonetic match rating or less than perfect phonetic match rating was 56% and 44%, respectively. For sixth-grade participants, the percentage of misspellings with either a perfect phonetic match rating or less than perfect phonetic match rating was 51% and

49%, respectively. For subsequent analyses, *phonetic match rating* consists of two categories: perfect and less than perfect phonetic match.

As Table 14 shows, there was no significant relation between phonetic match ratings and correction time for fourth- and sixth-grade participants. There was no significant difference in the amount of time participants took to correct misspellings with perfect and imperfect phonetic match ratings.

Table 14

Mean (standard deviation in parentheses) correction times of misspellings with perfect and imperfect phonetic match ratings by fourth- and sixth-grade participants

	Fourth-grade participants	Sixth-grade participants
	Mean correction time (sec)	Mean correction time (sec)
Phonetic Match Ratings		
Perfect	31 (45)	13 (21)
Less than perfect	21 (22)	19 (32)

As Table 15 shows, there was no significant relation between phonetic match ratings and percent of misspellings corrected properly by fourth- and sixth-grade participants. There was no significant difference in the percent of misspellings with perfect and imperfect phonetic match ratings that were corrected properly. The bigram ratios for misspellings were inversely related to the correction time ($r(40) = -.40, p < .05$ and $r(31) = -.38, p < .05$) for fourth- and sixth-grade participants, respectively. Misspellings with higher bigram ratios tended to be corrected in less time.

Table 15

Mean (standard deviation in parentheses) percent of misspellings with perfect and imperfect phonetic match ratings corrected properly by fourth- and sixth-grade participants

	Fourth-grade participants	Sixth-grade participants
	Percent misspellings corrected properly	Percent misspellings corrected properly
Phonetic Match Rating		
Perfect	74 (40)	74 (37)
Less than perfect	78 (33)	79 (23)

Table 16 shows the relation between bigram ratio and number of misspellings corrected properly for fourth- and sixth-grade participants. There was a main effect of the number of misspellings corrected properly (F (1, 24) = 9.80, $p < .01$). Misspellings that

Table 16

Mean (standard deviation in parentheses) bigram ratios of misspellings corrected properly and improperly by fourth- and sixth-grade participants

	Fourth-grade participants	Sixth-grade participants
	Mean bigram ratio	Mean bigram ratio
Misspellings corrected properly	0.67 (0.14)	0.72 (0.10)
Misspellings not corrected properly	0.60 (0.19)	0.60 (0.14)

were corrected properly tended to have higher bigram ratios than misspellings not corrected properly.

Summary of exploratory analyses for misspellings. Bigram ratios, but not phonetic match ratings, indicated differences in percent of misspellings corrected properly and in correction time. Misspellings that were corrected properly had higher bigram ratios than misspellings not corrected properly and misspellings with higher bigram ratios tended to be corrected in less time. There were no differences in grade level for these analyses.

Relational analyses between Composition Task, Transcription Skills, and Student Questionnaire and relational analyses between Questionnaire Items

Relations between transcription skills (i.e., spelling skill, typing skill) and the composition task variables were explored (i.e., story length, number of errors, correction rates, rate of using methods, and success rates).[15] For the fourth-grade group, two relations were found. A relation was found between story length and transcription skills (spelling skill ($r(35) = .57, p < .002$) and typing skill ($r(50) = .61, p < .002$)). Participants who had better transcription skills tended to write longer stories.

For the sixth-grade group, two relations were found. Inverse relations were found between participants' spelling skill and number of total errors ($r(32) = -.64, p < .002$) and number of misspellings ($r(32) = -.59, p < .002$). Participants who had greater spelling skill tended to commit fewer total errors and misspellings than other participants.

For both the fourth- and sixth-grade groups, there were no relations found between participants' questionnaire responses on different items of the questionnaire.

For both grade groups, there was one relation between participants' transcription skills and their questionnaire responses. A relation was found between spelling skill and

participants' reports of being good at spelling (fourth-grade: $r(34) = .60, p < .008$, sixth-grade: $r(32) = .81, p < .004$). Participants who reported that they were good at spelling tended to have better spelling skill than other participants.

For the fourth-grade group, there were no relations found between participants' questionnaire responses and composition task variables. For the sixth-grade group, there was one relation found between participants' questionnaire responses and composition task variables. An inverse relation was found between participants' reports of being good at spelling and number of total errors ($r(35) = -.61, p < .0005$). Participants who reported that they were good at spelling tended to commit fewer total errors than other participants.

Summary of relational analyses between composition task, transcription skills, and student questionnaire. For both grade groups, participants that reported they were good at spelling tended to have greater spelling skill. Fourth-grade participants who had better transcription skills tended to write longer stories. Sixth-grade participants who had greater spelling skill and who reported that they were good at spelling tended to commit fewer errors than other participants.

Discussion of Results

Interpretation of findings and Integration with literature

Research Question. The *research questions* posed in this study were: when do children choose to use the spell checker during the composing process and how successful are they at correcting errors when using the spell checker? To address this question, I observed fourth- and sixth-grade children's writing using a word processor and their error correction with the spell checker. I found that participants tended to use

the spell checker most often to correct misspellings and to correct themselves most often to correct the other errors. I also found that both grade groups were mostly successful at correcting errors when using the spell checker. These results suggest that children may choose to use the spell checker when correcting errors in the letter sequence of the word (as opposed to errors in capitalization, spacing, and punctuation) and that when they do choose to use the spell checker, they tend to be successful at correcting the error properly. In the section below, I will re-visit each of the main predictions by stating each prediction and the approach used to address it, followed by the relevant finding and its interpretation.

My first main prediction concerning children's use of the spell checker was:

I. Children will use a variety of methods to correct errors. These methods include correcting the error themselves (e.g., backspace and correct), using the spell checker (e.g., selecting an option from the list of suggestions), and a combination of correcting themselves and using the spell checker.

To address this prediction, I conducted a descriptive analysis of the frequency of use of different methods of correction. I found that participants from both grades used a variety of methods to correct their errors, including using the spell checker, correcting themselves, and a combination of methods. This result is as expected and is meaningful in several ways. First, this finding corresponds with the variability found in children's first attempts to spell words (e.g., variability in strategy use) (Kwong & Varnhagen, 2005; Rittle-Johnson & Siegler, 1999; Varnhagen et al., 1999). Just as children may

apply more than one strategy to the process of producing a spelling, so too do they apply various methods to correcting their spelling.

Second, this finding relates to the nature of the task as a problem-solving process in that children would use a variety of methods and resources to correct errors and sometimes these methods were used in combination for the same error. In some instances, children were unable to find a correct solution using only one method, and so they tried a different method or went back and forth between methods to arrive at the solution. Third, although speculative, this finding may relate to participants' implicit assumption or belief that tools such as a dictionary or the spell checker are not fool-proof and are not always effective. This belief could be based on prior experience with tool use. That is, participants may understand that given the fallibility of these tools, a singular approach may not yield success and it may require a combination of methods to properly correct the error. Fourth, teachers reported that, in terms of instructional practice, they prefer that students try several resources to check their spelling (e.g., spell checker, sounding out and re-writing, asking others) and so participants' instructional experiences on how to correct spelling errors may also relate to this finding.

My second main prediction concerning children's use of the spell checker was:

II. Children will choose to correct themselves more often than using the spell checker for errors that are not misspellings, but will use the spell checker more often than correcting themselves for misspellings.

To address this prediction, I conducted analyses to investigate differences in frequency of use of methods of correction for misspellings and other errors. I found that, across both grade groups, participants tended to use the spell checker most often to

correct misspellings and to correct themselves most often when correcting other errors (errors in capitalization (e.g., *santa* for *Santa*), spacing (e.g., *big.We* for *big. We*), and punctuation (e.g., *did'nt* for *didn't*)). Note that the errors classified as *other* consisted of errors in grammar as opposed to spelling (i.e., the letter sequence for the word was correct). Thus, the use of the spell checker may have occurred most often for misspellings because for these errors participants may not have produced or known the correct spelling for the word and chose to use this tool as a resource. By contrast, the other errors already contained the correct spelling and so using the spell checker to find the correct spelling would not be necessary.

This finding relates to the nature of the task as a problem-solving process in that when writers correct errors, part of the process of revising and editing their writing consists of diagnosing the problem (i.e., identifying the problem and determining the best way to go about solving it) (Flower, Hayes, Carey, Schriver, & Stratman, 1986). Although speculative, children's use of different methods to correct misspellings and other errors may suggest that they have identified the problem (in the case of misspellings, the problem is an error in spelling, and in the case of other errors, the problem is an error in capitalization, spacing, or punctuation) and consequently they have determined the most appropriate method for solving it. In turn, this finding also relates to the adaptability of children's approaches depending on the nature of the problem (Kwong & Varnhagen, 2005; Rittle-Johnson & Siegler, 1999; Varnhagen et al., 1999).

My third main prediction concerning children's use of the spell checker was:

III. Both spelling ability and ability to use the spell checker properly will increase across grade level.

To address this prediction, I conducted analyses looking at differences across grade groups in spelling ability and success rates of using the spell checker. I found that participants were successful at using the spell checker (86% success rate for both grade-level groups) and success rates did not differ across grades, even though spelling ability was greater in the sixth-grade group than in the fourth-grade group.

The finding that ability to use the spell checker properly did not increase across grade level was unexpected. More generally, developmental findings were lacking in this study. It is unclear whether we can interpret these groups as having any meaningful differences in task approach or performance. For example, although there was a difference in the correction time, there was no difference in the number of errors corrected properly across grades. From a practical point of view, fourth-graders were no less successful at using the spell checker as a group than sixth-graders. The lack of developmental group differences is somewhat surprising when considering the gains made in writing (e.g., Bereiter & Scardamalia, 1987), transcription (e.g., Graham & Harris, 2000) and spelling (e.g., Cassar & Treiman, 1997; Evans & Smith, 1989) across the upper elementary grades.

However, in addition to changes in cognitive development that support literacy skills, similarities or differences in experience should be considered. Both grade groups reported similar computer uses and experience (e.g., computer use in the home, using the computer for a variety of activities, writing with the word processor). Thus, based on the data I have, there is no indication that there was a substantial difference in experience that might suggest a relation to task performance. For example, the percentage of fourth- and sixth-grade participants who reported writing using a word processor as one of their uses

of the computer was comparable. Further, although a greater percentage of sixth-graders indicated they used the spell checker as a resource for checking spelling, I found that when participants chose to use the spell checker, regardless of grade level, they were mostly successful at correcting the error properly. It should be noted that the participants in my study appear to have similar experiences with and affinities for computer use as other young Canadians. Spears, Seydegart, and Zulinov (2005) surveyed 5000 Canadians in grades 4 to 11 on their uses of electronic media. Their survey results for fourth- and sixth-grade children indicated similar proportions of children engaging in similar activities (e.g., computer games, homework) compared to my study's participants. Studies with groups of students who have more variability in experience may provide a more interesting investigation of the learning process of students using a spell checker. This type of investigation may relate to the question of best instructional practice when introducing word processors and spell checkers as a writing tool.

It is important to consider how my study's findings on children's use of the spell checker correspond to the literature. I found that participants from both grades were very successful at using the spell checker, whereas MacArthur et al. (1996) reported a much lower success rate by students when using the spell checker. In particular, the descriptive analyses indicated that the spell checker was successful at suggesting the correct word, as opposed to the findings of the other studies (MacArthur et al., 1996; Montgomery et al., 2001). Further, the correct word was on the spell checker's list for the majority of instances when participants were successful. Thus, my finding that participants in both grades had a high success rate of using the spell checker may have been directly affected by the frequency of the correct word being in the spell checker's list. Note that the setting

for my study was naturalistic, in that participants produced their own writing and consequently their own set of errors. Thus, the nature and severity of the errors was in part determined by participants' word choice. It may be interesting to investigate whether grade differences in spell checker use occur when participants are required to write on a pre-determined topic and word choice is not entirely up to them (e.g., use of terminology or vocabulary related to a subject such as children writing a science report and needing to spell the word *chlorophyll*).

Another issue concerns the ordinal positioning of the spell checker's list of suggestions. The spell checker in Microsoft Word XP provides suggestions for error correction in a listing form. Researchers have suggested that this implicit ordering may be problematic for children, who may rely on the first word suggested in a list (MacArthur et al., 1996). However, I found that both grade groups were mostly successful at choosing the correct word on the spell checker's list, regardless of its position on the list. Instead of the correct word's positioning on the list, what may be more important is students' word recognition ability and their morphological knowledge (e.g., recognizing the correct word and deducing which words are inappropriate based on their meaning). However, it is possible that poor spellers who have difficulty recognizing the correct spelling may be influenced by this kind of ordinal positioning (MacArthur et al., 1996).

One final issue concerns the relation between error correction and error severity. Phonetic match ratings were not related to correction time or the number of misspellings corrected properly. These results most likely occurred because the misspellings coded as having an imperfect phonetic match to the correct word were mostly very close to a

perfect phonetic match (i.e., most phonemes were represented). However, several results indicate that bigram ratio was a better measure of error severity. Bigram ratios were related to the presence of the correct word on the spell checker's list and to the number of misspellings corrected properly. Further, mean bigram ratios were higher for the misspellings corrected properly than for the misspellings not corrected properly. These findings suggest that the higher the bigram ratio (i.e., the less severe the misspelling), the more likely the correct word appeared in the spell checker's list and the more likely that the misspellings were corrected properly. This finding is in agreement with Montgomery et al.'s (2001) finding that the spell checker's success rates were more efficient when the errors had similar letter strings to the correct spelling. Bigram ratios, as opposed to phonetic match ratings, may more accurately capture the severity of the misspelling, and in turn, relate to the spell checker's probability of suggesting the correct word because the ratio is calculated based on the number of correct bigrams. This calculation would be affected by errors in orthography whereas phonetic match ratings may only indicate errors in phonology. For example, the error *exsited* (excited) would be given a perfect phonetic match rating but not a perfect bigram ratio of 1.00.

Theoretical implications

Most research investigating the spelling process has focused on first-attempt spelling (e.g., strategy use when producing words). This study focused on the error correction process within the context of using the spell checker. When the correct word was in the spell checker's list, participants were usually successful at recognizing and choosing the word. This finding highlights the discrepancy between word recognition and production. Although participants may not have produced the correct letter

sequence, they were mostly successful at recognizing it. Because choosing the correct word from a list of suggestions is a problem-solving task (e.g., deduction) and a word recognition task, it may be important to incorporate problem-solving and word recognition skill, in addition to spelling skill, when discussing process of proofreading and correcting text for spelling errors in the word-processor context.

In my study, participants sometimes used a combination of methods to correct errors. One of these combinations consisted of going back and forth between correcting an error themselves and using the spell checker. Although speculative, one interpretation is that participants were aware of the spell checker's tendency to suggest words that are similar to the letter sequence, and in order to work within this tool's constraint, they have learned to systematically manipulate the sequence based on their knowledge of orthographic conventions. This conjecture highlights the idea of spell checker use as a problem-solving process and of implicitly learning through experience how to successfully use imperfect tools. Further, it emphasizes the role of the spell checker as a scaffolding agent, in that participants, working within their zone of proximal development, were able to achieve success using the spell checker that they might not otherwise have been able to achieve alone (Vygotsky, 1978).

It is an interesting question whether another tool, such as the dictionary, could serve as an equivalent within a child's zone of proximal development. Children in this study rarely used the dictionary and on the occasions when they consulted the dictionary, they had difficulty locating the intended word. In addition, dictionary use lengthened the amount of time needed to correct errors. Fourth- and sixth-grade children's seldom use of the dictionary is not surprising, given that frequency of dictionary use to correct spelling

tends to decrease across age in childhood (Beech, 2004). Therefore, the spell checker as a more interactive and responsive tool may serve as a better scaffolding agent for supporting the proofreading process than the dictionary.

Research implications

Different populations may have different levels of spelling skill (e.g., "normal" population as compared to population of students with learning disabilities) (e.g., MacArthur et al., 1996). Because spelling in the context of using a word-processor involves a specific person-environment interaction (i.e., person interacts with the spell checker as an environmental tool), the factors affecting this interaction could be varied in order to obtain a more accurate picture of the problem-solving process for different populations within this context. Studies with different populations may indicate the degree to which spelling skill, word-processing experience, writing experience or other person variables may predict success with using the spell checker. In addition, studies varying the environment (e.g., spell checkers designed for children's use, with speech recognition capability) may also point to tools that are better suited to specific populations.

From a developmental point of view, it may be interesting to conduct studies with younger students to investigate the relation of cognitive developmental processes to the problem-solving nature of the proofreading and error correction task. Longitudinal studies may indicate developmental or experiential milestones that are important for children's success at using the spell checker. Studies comparing group differences in age with similar levels of computer experience (e.g., second- and ninth-graders with similar levels of computer experience) or studies comparing group differences in experiences at a

similar age level (e.g., second graders with varying levels of computer experience) may also help to identify the importance of maturational and experiential variables to success at using the spell checker. In addition, studies investigating knowledge and skill differences relevant to the task (e.g., knowledge of orthographic conventions, typing skill) may also be useful.

Educational implications

The findings from this study have several educational implications. To discuss these implications, it may be helpful to consider what I might call an *expert spell checker user.* The expert spell checker user would have sufficient knowledge and command of the English language to create an error that is reasonably close to the correct spelling of a word (e.g., *laquadasical* for *lackadaisical*). The expert user would then, if necessary, be able to systematically manipulate the letter sequence of the error (e.g., recognizing that *qu* may not be appropriate, replacing *qu* with *c*, and changing the spelling to *lacadasical*), by applying knowledge of orthographic conventions and deduction skill, so that the correct word would appear in the spell checker's list of suggestions. Finally, the expert user would recognize the correct word and choose it from the list. This exercise in describing an expert user's approach highlights the knowledge bases and skills that would support the task of spell checker use. One educational implication would be to have teachers explicitly instruct students on the practice of manipulating the error's letter sequence. For example, teachers could prepare a step-by-step protocol for students to follow when using the spell checker. This protocol might involve verifying whether the spell checker has flagged a true misspelling, viewing the spell checker's list of suggestions and evaluating each one, and selecting a suggestion or if the appropriate

suggestion is not there, attempting to change the error so as to successively approximate the correct spelling. This latter step could be accomplished by focusing on the orthographic and morphological features of the spelling in order to isolate the areas of the letter sequence that need to be changed. After changes have been made, the student could re-check the spell checker's list of suggestions.

Although, it should be noted that explicit instructions may not be necessary for learning the importance of the error's letter sequence in relation to the correct word's letter sequence. Participants in this study had high rates of success at using the spell checker and for participants who used a combination of methods, there were instances in which the participant viewed the spell checker's list and the correct word was not present, then corrected the error themselves, and then went back to the list. Thus, this type of practice may be implicitly learned through experience (Siegler, 2005).

For students who are younger or who struggle with spelling, producing an error that sufficiently resembles the correct word's letter sequence may be problematic. For these students, spell checkers that can be designed to recognize more phonologically based attempts at spelling may be more appropriate.[16] If possible, spell checker programs that include a speech recognition component may be useful for helping the spell checker to identify and suggest the appropriate word for correction. However, regardless of the sophistication of the tool, students may continue to use the spell checker in conjunction with other methods when correcting their spelling.

Time on task may be a factor for students' writing in the word processor context. There was variability in the correction time for both grade groups and although successful at the end, some errors took several minutes to correct. During a twenty-

minute composition task, this may or may not be considered an effective use of time. Participants were instructed to try to correct any errors they made. During earlier stages of the writing process (e.g., first draft), it may not be suitable to focus on correction of mechanical errors. Another related factor to time on task is typing skill; in this study, for the fourth-grade group, typing skill was positively related to story length. Although not a primary focus of this study, participants' lack of touch typing skill may have affected writing speed and in turn, the writing process. However, just as handwriting shows steady increases in speed throughout the elementary years (Graham & Weintraub, 1996), I found that the sixth-grade group's mean typing speed was faster than the fourth-grade group's typing speed. Thus, although none of the participants possessed touch typing skill, there were developmental differences in the speed at which participants typed using the "hunt-and-peck" strategy.

Nonetheless, lack of touch typing when writing using a word processor may tend to slow down the transcription process. In this study, I found that fourth-grade participants who had better typing skill tended to write longer stories within the same time frame allotted than fourth-graders who did not have better typing skill. Further, approximately three-quarters of sixth-grade participants agreed with the statement that if they could type faster, then they would like writing on the computer more. This finding is in agreement with Kahn and Freyd's (1990) result that familiarity with the keyboard was found to be a factor in children's preference with using a word processor. Given these attitudinal data, teachers may wish to accommodate children by providing them with more time when writing with the word processor.

The error detection process remains a challenge for spellers (e.g., Figueredo & Varnhagen, 2004). In this study, participants did not attempt to correct any of the errors that the spell checker failed to flag (e.g., homophone and real-word errors). Application of morphological knowledge may be important for detecting homophone errors; in addition, strategies that may help to detect these kinds of errors include a careful re-reading of the text or asking a person unfamiliar with the text to proofread for errors (e.g., in a classroom setting, being asked to peer-review each other's writing in pairs prior to handing in a final copy).

Finally, the importance of investigating children's use of the spell checker may have implications beyond strictly identifying the factors affecting success with spell checker use and having a more comprehensive picture of the spelling process within a currently practical setting. An understanding of how children problem-solve and use academic skills during a task requiring application of knowledge and use of imperfect resources may have sustained importance given the rapid changes in defining technology, technological users, and user-friendliness of tools.

Limitations

The major limitations of this study were (a) the willingness and ability of participants to respond at all and to respond accurately during all tasks, and (b) the extent to which participants' behaviour in this study is an accurate reflection of their behaviour outside of this study. It should also be noted that the sample size was kept to a manageable number of participants and the task time was kept to the minimum necessary to collect sufficient data so as not to burden the school system.

This study's design had a naturalistic and observational setting. Participants were given a composition task and were free to write as they desired on a broad topic. Although having a naturalistic design was a benefit of the study, the errors produced were related in part to the participants' word choice. This relation may have limited the data and error analyses to words that participants felt comfortable using. Therefore, these results may not extend to tasks where they are required to write on an assigned topic requiring specific word usage (e.g., technical language, words related to subject matter). Studies designed to investigate children's spell checker use under different writing conditions would be useful.

For the analyses investigating relations between transcription skills, composition task, and questionnaire, Bonferroni corrections were applied to the alpha. Although it was necessary to apply this correction given the number of tests of significance for each data set, the more stringent alphas impose the risk of failing to find meaningfully significant results because of the stricter criterion for rejection of the null prediction. This hazard may in part account for the small number of significant results found between the tasks in the study. For example, I did not find a significant relation between spelling skill and success rates at using the spell checker or between typing skill and the number of other errors committed. The lack of these findings may reflect no relation between tasks in the population or alternatively, these findings may have been undetected. To increase the power of detecting meaningfully significant results, a similar study with a larger sample would be advantageous.

Compliance with Ethical Standards

The proposed study was conducted in accordance with the American Psychological Association's Guidelines for Ethical Conduct (American Psychological Association, 2002) and the Society for Research in Child Development's Ethical Standards for Research with Children (Society for Research in Child Development, 1991). In particular, parents were asked to sign informed consent forms. At the start of each testing session, the experimenter explained the study to the child participants in terms appropriate to their comprehension, and asked for their assent to participate in the experiment. The participants were informed that they had a right to withdraw without academic penalty at any point during the experiment. After the experiment, participants were orally debriefed by describing what the study was about and asking if they had any questions. The participants' confidentiality was preserved by assigning a participant code to each participant's data. While a final report of the study was submitted to each of the schools, individual results were not given out.

Endnotes

1. These studies were conducted with older populations: high school students (Kurth, 1987) and college students (Hawisher, 1987).
2. Because the primary focus of the dissertation involves children's writing as a solitary event (i.e., without access to people such as teachers, parents, or fellow students), I did not mention these people in my discussion of potential resources to support the spelling task in either paper or computer environments.
3. In line with achieving a balance between attaining sufficient power for statistical analyses and minimizing the costs of time and energy to the teachers and students in the schools, I aimed to have at least 30 children in each of grades four and six participate in the study.
4. Researchers have found children, as young as kindergartners, can benefit from and have enjoyable experiences using word processors without possessing touch typing skills (e.g., Kahn & Freyd, 1990).
5. The fourth-grade questionnaire results are based on 50 participants' data because two participants were not at school the day I administered the questionnaire. Although all 37 sixth-grade participants were administered a questionnaire, the results for the items that are unique to the sixth-grade questionnaire are only based on 23 participants' data because the remaining 14 participants were accidentally administered the fourth-grade questionnaire. The fourth-grade spelling test results are based on 37 participants' data; for 13 participants, the ceiling needed to calculate the score was not established because of experimental error and two participants were not at school the day I administered the spelling

test. The sixth-grade spelling test results are based on 34 participants' data; for 3 participants, the ceiling needed to calculate the score was not established because of experimental error.

6. Before implementation, the dissertation design included soliciting verbal retrospective reports from children on their error correction. However, during data collection, it became evident that experimenters were unable to solicit meaningful descriptions of error correction without asking potentially leading questions, and so these descriptions were not used in any analyses. The number of occurrences for soliciting verbal reports was low (21% of total corpus of fourth-grade participants' misspellings and 14% of total corpus of sixth-grade participants' misspellings), and so this procedure was unlikely to have dramatically affected the composition task.
7. Because children had familiarity using a paperback dictionary, and it was not clear that

   they had used an online dictionary prior to this study, I chose to include a paperback dictionary rather than giving them access to an online dictionary during the composition task.
8. For this method, because participants did not technically correct the error (i.e., they did not correct the error and retain the word), but instead chose to delete the error and switch to a different word, this method was not coded as correcting the error properly.
9. For some of the ANOVA analyses, the mean percent rather than mean number was used. For these analyses, it was more informative to analyze the data based

on the proportion of errors rather than the number of errors because it gave a better indication of success (e.g., if 7 out of 8 errors were corrected properly, the percent (i.e., 88%) may be more informative than the number (i.e., 7).

10. Although ANOVA analyses are often used to analyse results with the intention of making cause-and-effect inferences, my study involved a non-experimental design, and so cause-and-effect inferences are inappropriate. For example, my analyses may indicate differences in one variable as it relates to levels of another variable, but not as a *cause* of the other variable. For the ANOVA analyses, a Bonferroni correction was applied to the alpha in order to reduce the chances of spurious results. The alpha for the omnibus tests was set at 0.01. Whenever possible, for the ANOVA analyses, grade level was entered as a between-subjects variable.
11. Thirty-four, 41, and 24 fourth-grade participants used the spell checker, corrected themselves, and used a combination of methods, respectively. Twenty-three, 32, and 12 sixth-grade participants used the spell checker, corrected themselves, and used a combination of methods, respectively.
12. For the two additional analyses, errors consisted of errors where the participant may have attempted to correct the error using the spell checker in isolation or in combination with other methods.
13. For this analysis, the group sizes were small (e.g., less than 30 participants per group). Although this test is robust in light of this kind of deviation, this result should be interpreted with caution.

14. MacArthur and Graham (1996) used a more elaborate coding scheme where phonetic matches were given scores of 0 (no phonemes correct or only 1 phoneme correct), 1 (between a score of 0 and 2), 2 (only 1 phoneme incorrect) or 3 (all phonemes represented). When I used this coding scheme to classify the misspellings in my study, it became apparent that the vast majority of misspellings either had a phonetic match rating of 2 or 3 (i.e., either an almost perfect phonetic match or a perfect phonetic match). Thus, this variable in my study consisted only of two categories: imperfect or perfect phonetic match (i.e., score of 0 or 1).
15. A Bonferroni correction was applied to the alpha for the correlational analyses between the transcription skills, composition task and questionnaire. For each set of data the alpha was set to 0.05/# of tests of significance. For the analyses investigating relations between transcription skills and the composition task, the alpha was set to 0.002. For the analyses investigating relations between the questionnaire items the alphas were set to 0.02 and 0.002 for the fourth- and sixth-grade groups, respectively. For the analyses investigating relations between transcription skills and the questionnaire the alphas were set to 0.008 and 0.004 for the fourth- and sixth-grade groups, respectively. For the analyses investigating relations between the composition task and the questionnaire the alphas were set to 0.001 and 0.0005 for the fourth- and sixth-grade groups, respectively.
16. This type of design may be challenging. MacArthur et al. (1996) and Montgomery et al. (2001) did not find very good success rates for spell checkers that were contained in word processing programs targeted for students.

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Appendix A

PARAGRAPH FOR TYPING TEST

Manatees have been described as slow, and so ugly that they are cute. They often reach a length of ten feet and weigh a thousand pounds. Lengths of thirteen feet and weights up to 3,500 pounds have been recorded. Florida manatees are gray in color, have sparse hairs, and often have organisms attached such as algae or barnacles growing on their skin. Manatees have a streamlined shape. Their body is full, almost fat, in the middle, and narrows down to a paddle-shaped tail. Two small pectoral flippers on their upper back are used for steering, movement along the bottom of waterways, and bringing food to their mouths.

Appendix B

PARTICIPANT QUESTIONNAIRE – GRADE 4 **CODE #:**

Do you have a computer at home? YES _____ NO _____

What do you use the computer for?

(Check all that apply)

- Homework/school assignments
- E-mail
- Chat/Discussion rooms (for example, MSN)
- Internet surfing
- Downloading music
- Computer games
- Writing using the word processor (for example, Microsoft Word, Word Perfect)
- Webpage design
- Other, please specify: _____

Please indicate how much you agree with the following statements.

I'm good at spelling words.

1	2	3	4	5
strongly disagree		neutral		strongly agree

I like to write stories.

1	2	3	4	5
strongly disagree		neutral		strongly agree

When I grow up and have a job, I'm probably going to write with the computer a lot.

1	2	3	4	5
strongly disagree		neutral		strongly agree

When I don't know how to spell a word, I usually:

(Check all that apply)

- Ask my teacher
- Ask a classmate
- Ask someone in my family
- Look up the word in a dictionary
- Use the spell checker
- Sound out the word and re-write it
- Other: _____

Appendix C

PARTICIPANT QUESTIONNAIRE – GRADE 6 **CODE #:**

Do you have a computer at home? YES _____ NO _____

What do you use the computer for?

(Check all that apply)

Homework/school assignments
E-mail
Chat/Discussion rooms (for example, MSN)
Internet surfing
Downloading music
Computer games
Writing using the word processor (for example, Microsoft Word, Word Perfect)
Webpage design
Other, please specify: _____

Please indicate how much you agree with the following statements.

I'm good at spelling words.

1	2	3	4	5
strongly disagree		neutral		strongly agree

I like to write stories.

1	2	3	4	5
strongly disagree		neutral		strongly agree

When I grow up and have a job, I'm probably going to write with the computer a lot.

1	2	3	4	5
strongly disagree		neutral		strongly agree

I feel comfortable using a word processor, including its tools and functions.

1	2	3	4	5
strongly disagree		neutral		strongly agree

Writing on a computer is more fun than writing with pencil and paper.

1	2	3	4	5
strongly disagree		neutral		strongly agree

Using a computer to write just makes writing more difficult.

1	2	3	4	5
strongly disagree		neutral		strongly agree

If I could type faster, I would like writing on the computer more.

1	2	3	4	5
strongly disagree		neutral		strongly agree

When I don't know how to spell a word, I usually:

(Check all that apply)

- Ask my teacher
- Ask a classmate
- Ask someone in my family
- Look up the word in a dictionary
- Use the spell checker
- Sound out the word and re-write it
- Other: _____

The things I like about using a word processor are:

(Check all that apply)

- Allows me to write faster
- Allows me to delete words easily
- Allows me to cut and paste sentences
- Has a spell checker
- Has a grammar checker
- My writing looks neat and tidy
- Other people can see my writing on the screen
- I get to work with other students at the computer
- I get to print out my work when I'm done
- Other, please specify: _____

I find the word processor frustrating to use because:

(Check all that apply)

- It's hard to type using the keyboard
- I'm not sure how to use all of the tools
- I sometimes get confused by all the options in the pull-down menus
- I sometimes press the wrong button and I can't seem to fix my problem
- I can't share my work easily with another student
- I forget to save my work
- Other, please specify: _____

Appendix D

TEACHER QUESTIONNAIRE **CODE #:**

Teacher Background

Grade(s) I teach: ____ Subject(s) I teach: _____ # years I've been teaching: ___

Teacher's preferences

Please indicate your preference for what resource students should use to proofread text for spelling errors.

(Check all that apply)
Ask a classmate
Ask their teacher
Ask someone in their family (if doing homework)
Look up the word in a dictionary
Use the spell checker
Sound out the word and re-write it
Other, please specify: _____

Please indicate the degree to which you agree with the following statements.

If students are using the word processor, I encourage them to use the spell checker to proofread their writing for spelling errors.

1	2	3	4	5
strongly disagree		neutral		strongly agree

If students are using the word processor, I don't allow them to use the spell checker to proofread their writing for spelling errors.

1	2	3	4	5
strongly disagree		neutral		strongly agree