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ABSTRACT

This study examined the impact of word processors on the writing of eighth grade students experienced in computer use. Four classes of students (n=111) were asked to write one expository paper on the computer and another paper on a similar theme by hand in a repeated measures research design that controlled for effects of order of writing (on or off the computer first) and differences in difficulty of topic. Draft and final versions of handwritten papers were transcribed and printed. Computer written papers were printed in the same typeface so that a reader could not tell whether a paper was a draft or final version written on or off computer. Papers were scored on four key characteristics by trained raters. A multivariate analysis of variance revealed that computer written papers were rated significantly higher than handwritten papers. Moreover, the papers were judged superior on all four scales when follow-up univariate analyses of variance were performed. Students were more apt to make microstructural changes to their work, such as correcting punctuation, when writing on the computer, as opposed to macrostructural changes such as block movements of text. Data further indicate that students continuously revised and edited their work at all stages of the writing process, with most of the revision done in the initial drafting session, making the traditional distinction between draft and final versions of a piece less meaningful. It is concluded that better quality writing is produced on computers than using paper and pencil alone. (50 references) (DB)

Effects of Word Processing on Students' Writing in a High Computer Access Environment

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Abstract

Word processors appear to offer many advantages for the student writer. These range from eliminating the drudgery of recopying text during the drafting stages and encouraging a more fluid and recursive writing style, to providing professional style printed copy in which students can take pride. The extent to which these advantages lead to better writing, particularly with younger children, is not clear from the literature, however. Nor are much research data available on how word processors affect the actual writing process.

This study partially replicates work done by the authors that examined the impact of word processors on the writing of eighth grade students experienced in computer use. Four classes of students (n=111) were asked to write one expository paper on the computer and another paper on a similar theme by hand in a repeated measures research design that controlled for effects of order of writing (on or off the computer first) and differences in difficulty of [illegible]. Draft and final versions of handwritten papers were transcribed and printed. Computer written papers were printed in the same typeface so that a reader could not tell whether a paper was a draft or final version written on or off computer. Also, when [illegible]dents were writing their papers on computer, a sample (n=40) of them had their work recorded on "electronic video tapes" using ScreenRecorder–an unobtrusive software utility running in the background.

Papers were scored on four key characteristics by trained raters using a holistic/analytic scale. A multivariate analysis of variance revealed that computer written papers were rated significantly higher than handwritten papers. Moreover, the papers were judged superior on all four scales when follow-up univariate analyses of variance were performed. The ScreenRecorder data revealed that students were more apt to make microstructural changes to their work such as correcting punctuation or inserting several new words into existing text when writing on the computer, as opposed to macrostructural changes such as block movements of text. These data further indicated that students continuously revised and edited their work at all stages of the writing process, with most of the revision being done in the initial drafting session, making the traditional distinction between draft and final versions of a piece of writing less meaningful.

The study concludes that middle level students experienced in using word processors were able to produce better quality writing on computer than they could using paper and pencil alone. This outcome was obtained despite the fact that few of the students using word processing made macrostructural revisions to their work. While the reason why students are able to produce better quality writing on computers is not entirely clear, the authors suggest that the graphical user interface

of the computers provided a facilitating environment for novice writers to experiment with many different ways of expressing themselves. In addition, the students' extensive prior experience with word processing likely served to develop their ability to use those features of the software that facilitate editing and revising.

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Preface

Four years ago the research site was the recipient of a large grant of microcomputers from the Apple Canada Education Foundation. The principal and staff developed a plan to integrate the computers into the grades 7 and 8 communication arts and social studies programmes during the first year of the grant, and afterward to extend their integration to other subject areas and lower grades as more hardware became available.

During the first year of the grant teachers began to report that significant learning was occurring among students and that their attitudes toward their work became very favourable because of the new technology. As a result, we were asked the following year by the school's principal to document some of the the changes that teachers saw happening. In consultation with the staff we developed a research plan that compared the writing of grade 8 students using the computer and working by pencil and paper. This research was published as Technical Report 90-1 of the Centre for the Study of Computers in Education (Owston, Murphy, & Wideman, 1990). The findings gave support to the notion that students, when given adequate opportunity to use microcomputers, are able to produce better quality writing on computers than by hand as judged by trained raters.

Our research attracted the attention of the Halton Board of Education and the Ontario Ministry of Education both of whom were developing computer implementation policies and projects. A formal agreement was negotiated with these two bodies that called for our original writing research to be replicated with the next year's cohort of grade 8 students. This Technical Report describes that replication. Also part of the agreement was a commitment to carry out a longitudinal study on the development of Primary/Junior level students' writing when they have ready access to technology. This research has begun and future Technical Reports will describe it.

The authors would like to thank the Halton Board of Education who encouraged open, independent inquiry on computer use in one of their schools, the staff and students at the research site who enthusiastically participated, the Apple Canada Education Foundation who provided the computers that made this research possible, and to the Ontario Ministry of Education who generously funded our research. The views expressed in this report are not necessarily those of the participants or funder, but are those of the authors who take sole responsibility for them.

Introduction

Why word processing in the classroom?

As computers become more common in the classroom, teachers at all levels are beginning to have their students both compose and revise texts using word processing software. There is a considerable body of anecdotal reportage and testimonial to the effect that word processing can have a positive impact on the quantity and quality of students' writing and revision (Bernhardt, Wojahn, & Edwards, 1988; Collier, 1983; Engberg, 1983; Fisher, 1983; Rodrigues, 1985). And it has been argued that several of the features and capabilities provided by word processors can make writing and revising easier and more effective. Word processing software can create a flexible and powerful environment for revising text; writing segments varying in length from one letter to several paragraphs can be deleted or moved with a few keystrokes or mouse actions. The relative ease of such operations may encourage students to revise more frequently and extensively. The potential impact of word processing on revision strategies has considerable significance, since revision has been shown to be one of the most important components of the writing process, and one that clearly distinguishes novice from expert writers (Bereiter & Scardamalia, 1987; Pea & Kurland, 1989). Research on revision has found that experienced (expert) writers revise extensively at the sentence and paragraph level, and that their revisions focus primarily on the substance, form, and shape of their argument. Students, by contrast, employ revision chiefly to correct perceived errors in syntax or failures to conform to conventional, teacher-dictated rules of form. Revision at a deeper level involving textual reordering or addition is rarely carried out (Bereiter & Scardamalia, 1987; Sommers, 1980). It has been suggested that by eliminating the drudgery of recopying a composition, and by allowing for far easier text modification, text editors can decrease student resistance to revising and encourage a more fluid and recursive writing style (Collier, 1983; Dickenson, 1986; Hooper, 1987; MacArthur, 1988). There is already some evidence that the effort of rewriting by hand may be a serious impediment to revising (Daiute, 1986).

Other elements of the word processing environment are thought to aid student writing. The public nature of the screen display may prompt students to read each others' work and so promote more peer review and editing (Dickenson, 1986; MacArthur, 1988). Screen displays may facilitate the young writers' development of a sense of their audience, perhaps by psychologically distancing the creator from his or her work (Hooper, 1987). And the ready availability of neatly printed, legible output may heighten students' pleasure and pride in their composition by eliminating any sense of failure generated by poor penmanship (MacArthur, 1988). Students' ability to produce reports, newsletters, and "books" with a polished look for a real audience may promote a perception of writing as a meaningful form of communication which has a real personal value, as something in which the student can take pride (Bruce, Michaels, & Watson-Gegeo, 1985; MacArthur, 1988).

Some writers have speculated that certain elements of word processing environments may actually be detrimental to the development of mature writing practices. The inability of the writer to see the entire composition on the screen at one time, and the lack of necessity to recopy (and thus reread) drafts, may discourage deeper level revisions of content and structure (Dickenson, 1986; Hawisher, 1986, 1987; Hult, 1986; Kurth, 1987). If students are not competent and practiced in the various editing procedures that the software supports, the cognitive demands of managing the interface may inhibit effective revision by diverting attention and resources away from the substance of writing (eg. Cochran-Smith, Paris, & Kahn, 1991). Alternatively, the complexity of the higher level editing procedures for moving and changing blocks of text may discourage children from attempting comprehensive revisions they would otherwise undertake. Students may make only surface level changes such as spelling and word substitution because they are much easier to carry out (Joram, Woodruff, Lindsey, & Bryson, 1990). This may be especially likely when character based word processors which require the use of a complex sequence of cursor and command-key sequences for block editing, such as WordPerfect, are used. Even the lack of typing skills may interfere with higher order processes involved in composing, adversely affecting students' writing (MacArthur, 1988). Recent research suggests that students are unlikely to master keyboarding and text editing skills without the benefit of direct instruction (Britten, 1988; Larter, 1987; Joram, Woodruff, Lindsey, & Bryson, 1990), and that this lack of skill does distract them from their real task (Dalton, Morocco, & Neale, 1988).

Research in word processing

Researchers are beginning to study the effects of word processing on student revision practices and writing quality, and the results to date have been equivocal. In a recent review of the literature, Hawisher (1989) concludes that texts tend to be longer when written on a computer, and the finished products have fewer mechanical errors. It is less clear if students using word processors engage in more revision or if the quality of word processed text is superior; roughly equal numbers of studies support opposing positions on both of these issues. Improved text quality has been most consistently found in studies that used college-age subjects (e.g. Bernhardt, Edwards, & Wojahn, 1989; Sommers, 1986; Teichman & Poris, 1989). When pre-college students are used as subjects the results are more contradictory. So few quantitative experiments have been undertaken with younger students, and the extant studies are often so flawed, that the current confusion is not likely to be permanent. More generalizable conclusions are likely to emerge as findings from future investigations add to our knowledge. In one widely cited study, Daiute has examined the revision processes and writing quality of 57 grade 7 and 9 students, all of whom had extensive word processing experience (Daiute, 1986). She found that students corrected more mechanical errors but made fewer meaning-level revisions when they wrote by hand. Final drafts of computer written work were longer on average than handwritten finals, usually because students had added new, unrelated material to the end of their drafts. Final computer-created essays were rated slightly higher in quality than handwritten ones, but this may not be an interpretable result; Daiute contends that the higher scores may be an artifact of the greater length of computer-produced work.

Kurth (1987) examined the work of a class of grade 10 and 11 students taking a composition course. No difference was found in either essay length or amount of revision activity between the word processing and control groups. In a larger experimental study using 120 fifth grade students, Woolley (1985) discovered no differences in the quality of student writing between those who wrote at the computer for sixteen 45-minute periods and those who worked with paper and pen. More encouraging outcomes were reported by Dalton and Hannafin (1987). In their study of 80 low achieving grade seven students, those who used simple word processing software showed greater gains in writing quality and engaged in more revision than did their peers working off-computer. A larger experiment employing over 200 fourth and fifth graders as subjects had the same two findings (Moore, 1987). Qualitative analysis of the revision characteristics for a subsample of the students studied indicated that those using word processing made more meaning-related changes in text than did their peers. In another experimental study, Larter (1987) found that grade one and three papers written on the computer were rated higher on ideas, organization, syntax, and spelling. Only surface-level features of word choice, syntax, and spelling were rated significantly higher for grade six computer-written papers.

The impact of word processing on the writing quality and revision practices of students with extensive, longer-term experience composing on computers has recently been investigated by Owston, Murphy, and Wideman (1990, 1991a, 1991b). Four classes of grade 8 students were asked to write a story on the computer and another one off the computer in a counterbalanced research design which controlled for order effects. The stories were narrative yarns relating tales of "great strength" or "great courage". Papers were scored on four dimensions using a holistic/analytic scale. The computer written stories were judged to be of significantly better quality overall and better on the competence and mechanics scales. Students also wrote significantly longer papers on the computer and they exhibited more favorable attitudes toward writing in general and toward editing when using the computer. No differences in textual coherence of the papers written on and off computers were found, and only one surface feature, spelling, was found to be better on the computer papers.

The findings of several recent studies suggest that the pre-existent levels of editing and revising skill students bring to computer-based writing contexts can be a significant determinant of the degree to which their writing may benefit from the use of word processing (Cochran-Smith, 1991). The mere presence of tools and procedures that can ease the task of meaningful revision may not be enough to engender better writing practices in students who have used only linear, sequential modes of composing in the past. There are some indications that young writers tend to revise in the ways they already know when they take up word processing, bringing their old habits to the new medium (eg. Kane, 1983; Wolf, 1985). For those students at an appropriate stage of development in their writing ability, however, certain studies suggest that word processing may serve as a catalyst to promote further growth (eg. Broderick & Trushell, 1985; Pearson & Wilkinson, 1986). But other novice writers may not have the capability to utilize the potential benefits the computer brings to the writing process unless they are taught how to edit and revise effectively. There is some empirical support for this position. Evans looked at the use of word processing in two contrasting junior-level classes—a process writing class and a skills writing class. Children in the skills class wrote more after the introduction of word processing, but did no more editing than before. In the process class, the results were exactly opposite: students wrote no more, but did do more meaningful editing, something which had been taught in the class. Those in the skills class had not been taught how to edit. Cochran-Smith (1991) cites two doctoral studies (Flinn, 1985; Kahn, 1988) which have found that word processing can improve the quality of revision over that in handwritten work, but that the nature of the revisions undertaken reflect the types of editing and revision practices taught in the ongoing writing instruction.

Limitations of current studies

There are significant limitations with some of these studies which make interpretation of their findings problematic. The majority of these investigations took place over a relatively short period of time, using students who had no or very limited experience with word processing prior to the study (Hawisher, 1989). In the light of the above discussion about the need for keyboard and editing-sequence facility before student attention can turn to substantive writing issues, it is questionable whether such limited exposure to on-computer composition can be expected to have a significant impact on the quality of student writing and the extent of revision activities. At any rate, most of the extant research does not address what is perhaps the most salient issue, the longer-term effects of extensive on-computer writing. It may be (for the reasons discussed earlier) that considerable instruction and experience working in one word processing environment is needed before some students can begin to benefit from use of the new medium.

Several of the research reports fail to provide critical information about the experimental contexts that is needed to meaningfully interpret their results. Levels of student competence in keyboarding and editing procedures, potentially confounding factors, are not discussed. In many of the quantitative studies it is unclear exactly how word processing has been integrated into the writing curriculum and pedagogy, making it impossible to determine the contribution of the instructional element to the reported outcomes.

A third limitation of many of the current studies lies in the nature of the word processing software used, which has usually been character-based and command-line or command-key driven. These character-based environments do not offer the ease of block editing and movement of some of the newer, more advanced GUI (graphical user interface) word processors that make use of mice, such as those that operate in the Macintosh and Windows environments. Anecdotal evidence and human interface studies both suggest that younger students may find the new environments easier to master than the character-based versions of WordPerfect or Bank St. Writer. The GUI writing tools have the added advantage of display veracity (boldface appears bold, etc.) and can readily incorporate graphics elements, both features that may strongly appeal to younger students. A study by Haas (1989) found that writers using advanced workstations with GUI word processors and mice produce longer texts than those working with character-based text editors on regular PCs, and the quality of their writing was significantly higher.

Finally, few investigations to date have offered any detailed comparative analysis of the forms of the editing and revision practices students employ in their writing beyond the broad categorizations provided for by coding schemes such as the widely used classification protocol developed by Faigley and Witte (1981). A deeper understanding of the processes associated with computer-based writing and editing will require greater analytic differentiation and integration than these schemes can provide. And because virtually every analysis of computer-based revision has used the technique of contrasting the changes between draft and final documents created in on and off computer writing, critical elements of the editing and revising process which occur at the point of utterance are being lost. There is much qualitative and anecdotal evidence to suggest that many substantive changes may be made at the initial point of text creation when word processing is used, which the study of printed drafts fails to capture (Cochran-Smith, 1991). Current studies may be excluding "the very aspect of word processing that makes it unusual" (Cochran-Smith, 1991, p. 126).

The present study

The present study was designed to overcome some of these limitations. First, it addresses the question of whether students experienced in working in an advanced GUI-based word processing environment produce a higher quality of expository composition when working on computer than they do when writing off computer. In so doing, it complements and partially replicates our earlier work in which the effects of word processing on narrative composition was examined using a similar repeated measures design (Owston, Murphy, & Wideman 1990, 1991a, 1991b). The nature and processes of on-computer revision are also explored in some detail with the aid of a real-time screen recording utility which allows a complete analysis to be made of all editing and revision made during all stages of the writing process, not simply between drafts. The subjects in this study had extensive training and experience in word processing, had been using computers regularly for their writing activities for several terms, and were competent keyboard operators who knew how to use the editing features of the software, making it possible for us to examine some of the longer-term results of word processing in the writing of students relatively comfortable in the word processing environment.

Method

Subjects

Four classes of eighth grade students in a K-8 public school in which computer use had been extensively integrated computers into the grade seven and eight communication arts curriculum served as subjects for the study. These students had been using computers for word processing in communication arts for four 40 minute periods every six school days for a year and a half prior to the research. During this time each student had unrestricted access to a Macintosh computer.

Two teachers, Jill and Barry, each taught communication arts to two of the classes. Both had been using a process approach to the teaching of writing. The study commenced about two thirds of the way through the school year. By that time Jill had assigned about a dozen writing projects to her students. Jill followed a very consistent format for her writing work. A theme or topic was introduced through the presentation and discussion of thematic materials and group prewriting activities were undertaken. Students would then work on a draft composition on the assigned topic. All writing was done on the computers using Microsoft Works, software which includes a fairly simple word processor that supports mouse-based editing and uses a menu command interface for file manipulation and formatting. Drafts were reviewed by two peers (referred to as "writing partners") who pointed out mechanical and syntactical errors, commented on the writing quality, and made suggestions for improvements. Following this peer editing, the paper was reviewed in conference with the teacher, who addressed issues of content, coherence, and style as needed. All the modifications were then made in the text file by the students using the editing capabilities of the word processor, and final version of the compositions would be printed for inclusion in the students' writing folder or display on the classroom walls.

Barry's writing curriculum diverged from Jill's in several respects. He had his students write proportionality more descriptive and expository compositions and fewer narratives. The 15 or so papers that his students had written by the time of the study were equally divided between the three paper types. Because Barry taught science in addition to communication arts, he would sometimes integrate his writing assignments into current science units, something which Jill did not do. Within a writing topic area, Barry's students were given some leeway in picking aspects of the topic to write about that corresponded with their own interests and knowledge. Barry used a similar process pedagogy to Jill's the major difference being that he would only conference with students about their drafts when he felt there was a need for it, the result being that students did not always discuss their drafts with him. He would also be more likely to point out errors in spelling and grammar observed on a student's screen during the drafting process than Jill, who would usually wait to see if the peer editing sessions would attend to these problems.

Procedure

The students' facility with the word processing module of Microsoft Works was first tested by having all classes edit a simple test document file which contained several errors. The test assignment distributed to the students can be found in Appendix A. It required students to correct the apparent errors, use the program's spelling checker, and move a block of text from one location in the document to another. As students worked in the computer lab, their level of mastery was assessed by several observers. All appeared able to key in words at a reasonable rate (equivalent to careful writing by children of that age), although only a minority used all ten fingers to do so. Only a few students in each class needed any assistance from the teaching staff to successfully complete the exercise. The great majority could use the spell checker effectively and knew how to edit a text block using the mouse to select text and menu commands to cut and paste it to a new location. Individual instruction was provided to the few students who were initially unable to complete any of the tasks until proficiency in the task was gained.

A within-subjects repeated measures design was employed for the experiment. All students wrote position papers on the environmental effects of "tire fires" and "oil spills". One was written on computer, the other by hand. Four classes at the grade 8 level (n=111) participated, allowing the order in which students wrote the papers and whether they wrote first on or off the computer to be different for each class so as to counterbalance any potential order effects. Source material in the form of newspaper and magazine articles describing the recent Exxon Valdez oil spill and a major fire at as nearby tire dump were made available to all students by means of posterboard displays that were used in all classes. In order that the students have a strong sense of purpose and audience for their work, they were told that their tire fire essays would be sent to the Minister of the Environment and their oil spill papers to the president of Exxon.

Teachers followed a specific set of instructions for introducing the assignments (see Appendix B). In order to provide sufficient time for the students to write without feeling time constraint pressures, they were given 90 minutes to generate a first draft. (All of the experimental tasks were integrated into the normally-scheduled communication arts classes.) At the end of the period drafts were collected or printed, and all handwritten drafts photocopied so that all originals could be returned to students for work in the next writing session. In this second session, which occurred within three school days of the first, students were asked to revise their work, and told that they had ninety minutes to complete their papers. The teachers again followed instructions provided by the researchers for leading this session (see Appendix B). Students were allowed to discuss their work with their writing partners if they wished, but did not consult with their communication arts teacher about their essays. They were allowed to use their spell checkers when working on the computer, and to use dictionaries when writing with a paper and pencil. Final papers were collected. The process was then repeated for each class using the remaining topic and writing condition (on or off computer). Thus for each subject there were four papers at the end of the study; a draft and final prepared using word processing and a draft and final on another topic written by hand.

Scoring of Writing

Student handwritten work was transcribed into a computer and all work was printed out in the same style so that a reader could not tell whether a student paper was a draft or final version written on or off computer. The researchers trained two teachers to rate the students' writing using the *Scale for Evaluating Expository Writing* developed by Quellmalz (1982). This is a holistic/analytic instrument that has six-point scales for assessing four dimensions of writing—*competence, focus/organization, support*, and *mechanics*. The dimensions are defined in Figure 1. Quellmalz (1982) reports interrater reliabilities for trained observers of .89 to .91 for the four scales of the measure. A description of the scale levels in given in Appendix C.

Scale	Definition
General competence	The overall, or holistic, impression of a piece of writing as to how clearly it communicates a message to the reader.
Focus/organization	The extent to which the topic is clearly indicated and developed in an organized manner.
Support	The quality (specificity and amount) of the support provided for the paper's theme both within each paragraph and throughout the paper.
Grammar/mechanics	The extent to which errors interfere with the writer's effectiveness in communicating.

Figure 1 Definitions of subscales of the Scale for Evaluating Expository Writing

The raters were trained by the investigators using procedures similar to those described by the National Council of Teachers of English (Myers, 1980). The training consisted first of having the teachers study the scale definitions and discuss any questions they had about them with the researchers. The teachers then began scoring practice using sample papers, discussing their rating rationale for each in light of the researchers' ratings of the same papers. Raters continued training on sample papers until their ratings were in complete agreement with those of the investigators for two consecutive papers. These rated papers were then made available for consultative purposes during the scoring sessions to serve as rating benchmarks. Researchers were present during the scoring sessions to monitor the ratings process and assist the raters in maintaining rating consistency. All papers were scored by both raters. For each paper, the ratings given by both raters for each of the four scales were averaged in order to set the papers' final scores.

Process Data Collection

In order to provide data for a detailed analysis of student writing revision as it occurred on the computer, real-time recordings of all the word processing sessions of a random sample of 40 students were obtained. These recordings were made using ScreenRecorder software, which runs unobtrusively in the background of the word processor and saves to disk an "electronic video" that can be played back to view the creation of the piece of writing from start to finish at any desired speed. These "video tape" segments were coded into process categories and subject to quantitative and qualitative analysis. The nature of this analysis is discussed in the Results section.

Results

The final scores on the four dimensions of writing were analysed using a doubly multivariate repeated measures MANOVA design. Complete data sets for 68 were available, due to student absences. Computer written papers were scored significantly higher in quality than handwritten papers ($F(4,61)=4.17$, $p=.005$). Univariate analyses of variance revealed that the scores for all four of the individual scales were significantly higher for the computer condition (see Table 1). Examples of papers rated at the various scale levels can be found in Appendix D.

Table 1
On and Off Computer Final Scores on the *Scale for Evaluating Expository Writing* (n=68)

Scale	On computer		Off computer		
	Mean	SD	Mean	SD	t
Competence	3.88	.84	3.57	.82	3.85***
Focus	3.68	.67	3.38	.77	3.56***
Support	3.57	.79	3.27	.84	3.17**
Mechanics	3.99	.86	3.65	.82	2.40*

*$p<.05$ **$p<.01$ ***$p<.001$

The lengths of the computer-written and handwritten final papers were compared using a paired t-test. The mean lengths in words for the two paper types (on computer mean = 199.32, off computer mean = 199.20) were not significantly different (t (104)=.01, $p=.994$), but the word processed compositions showed much greater variance in their length (on computer SD = 155.32, off computer SD = 100.12).

The relationship between students' language arts achievement as reflected in their second-term communication arts grades and the differences in the overall competence of their writing on and off computer was also investigated. Each student's overall competence score for the final version of their off computer paper was subtracted from their competence score for the final version of their word processed paper in order to compute a difference score. These scores were then used as the dependent variable in a regression analysis, with the students' communications arts grades for the second term being used as the independent variable. The grades proved to have no significant value in predicting the direction and degree to which a student's writing quality differed across the two writing conditions ($F(1,41)=1.32$, $p=.256$). In other words, no difference was found between students at various levels of language arts achievement in the degree to which their writing benefitted from the use of word processing .

ScreenRecorder Data Analysis

Although 40 students were monitored using the ScreenRecorder software, a complete data set was available on 19 students. This sharp mortality rate was due to student absences on one of the four data collection sessions or to improper execution of file-saving and/or program exiting procedures. Despite these sampling difficulties, the patterns in the data warrant description because of possible insights that can be gained from the unobtrusive data collection instrument.

The data were coded on four major categories: (a) text scanning mode, (b) the use of software features as indicated in the menu-bar icons or words, (c) the type of text deletion, and (d) the nature of text incrementations or additions. These are discussed below.

The text-scanning mode incorporated all observable cursor movements which did not involve text additions, deletions or substitutions. The following text-scanning modes were observed: (a) cursor movement (backward and forward), (b) mouse movement (backward and forward, (c) page up or page down movements, (d) moves to the beginning or ending point of the text, and (e) highlighting of a text through blocking.

The menu-bar category included the following: (a) an "apple" icon which permitted access to desk accessories such as the calculator or control panel, (b) the label "file" which allowed access to options such as opening, closing and printing files, (c) the label "edit" which made available editing options such as cutting, copying and pasting, (d) the windows menu, (e) the search menu, (f) the "format" label which makes available layout features, (g) the "spelling" label which permitted dictionary checking and thesaurus procedures, and (h) the "macros" label which made available procedures for writing and storing macros.

In the Microsoft Works program, text deletion can occur only by backspacing or by blocking and cutting. Text additions could take one of two forms: (a) an insertion into previously written text, or (b) the continuation of writing from the last text endpoint on the screen.

For each of the four major coding categories, the amount of text involved in the specific keyboard action was noted in terms of the number of letters, words and t-units (an independent clause with all of its dependant clauses [Hunt, 1965]). Spaces and punctuation marks were counted only for deletions and insertions.

ScreenRecorder Data Patterns

Subsequent to analytical coding, the data were examined to determine whether there were any patterns. Three frames guided the search for patterns. First, the frequency of use of the coded features was tabulated. Second, the amount of text involved in each keyboard action was examined, and finally, patterns of use for several individual students were examined.

Frequency of use of coded keyboard actions

Table 2 summarizes the frequency of use of the coded keyboard actions. The distinction of draft/final is maintained because this is the distinction under which students created the texts.

Table 2

Frequency of Keyboard Actions (n=19)

Keyboard Action	Draft			Final		
	Mean	Freq. of non-use	Range	Mean	Freq. of non-use	Range
Text scanning						
Backward cursor	4.05	2	0-9	1.58	12	0-7
Forward cursor	4.53	0	1-12	2.84	9	0-14
Backward mouse	1.95	7	0-8	1.63	7	0-16
Forward mouse	3	6	0-12	4.47	4	0-23
Page up	0.32	14	0-2	0.89	7	0-2
Page down	0.47	12	0-3	0.47	11	0-2
Beginning point	0.89	11	0-7	0.47	10	0-1
End point	5.16	2	0-8	2.47	1	0-11
Block highlight	1.63	8	0-6	0.89	12	0-6
Menu-bar						
Apple	0	19	—	0.16	16	0-1
File	0.84	9	0-3	2	5	0-8
Edit	0.37	14	0-2	0.68	14	0-4
Windows	0.05	18	0-1	0.05	18	0-1
Search	0.26	15	0-2	0.37	14	0-3
Format	5.11	2	0-16	0.74	12	0-4
Spelling	1	5	0-4	0.74	7	0-2
Macros	0	19	—	0	19	—
Text deletion						
Backspace	31.47	0	1-60	10.84	2	0-55
Block	0.21	15	0-2	0.05	18	0-1
Text addition						
Insert	4.14	2	0-11	5.58	5	0-34
Text entry	34.63	0	14-58	7.84	10	0-47

Text scanning mode. Under the text scanning mode categories, several patterns are noteworthy. The first patterns relate to text scanning through the use of relatively small-scale keyboard actions. The actions considered within this area are backward and forward cursor and mouse movements. There is a near halving of the mean frequency of use for backward and forward cursor movements from draft to final, and a marked increase in the number of students choosing not to use cursor movement in the final session. For mouse movement, the changes are less dramatic; however, the range of the frequency of use is much greater. This increase in range is attributable to one student who heavily used this keyboard action in the final session. The emerging pattern from backward and forward cursor and mouse movements is that more students do more of these types of scanning during the earlier phases of composition.

Analysis of the patterns of movements around the text through more global action highlights both differences and similarities in draft and finalization sessions. More writers travelled backwards through the text using the page-up feature in the final session; however, as the ranges and frequencies of non-use indicate, this feature was not very heavily used. This pattern seems logical. Since students had more text to work with in the final session and that text usually filled more than one screen, the use of the page-up feature was necessary to scan text not available on the screen. The increase in the frequency of use of this global scanning feature may be related to the decrease in the use of micro-scanning features such as mouse and cursor movements.

The page-down feature was used with similar frequency by a similar number of students in draft and final sessions. The use of this feature may be related to the fact that on the two-page texts written in this study, when this feature was used, the text was visually available on screen from its beginning. Writers could then move the cursor from its last position to an alternate position in order to add or delete text. It seems likely that they then worked their way down to the endpoint of the text making revisions as they went along. Consequently, their use of the page-up feature would likely be more frequent than their use of the page down feature.

Despite the frequency of cursor, mouse, and page movements, over half the students did not observably return to the immediate beginning poin' of their texts in either the draft or final stages. However, this may not have precluded a reading from the beginning point, given the nature of computer screen display. More students returned to the endpoints of their text more often in the drafting session. This observably documents that the students often left the endpoint of the text to go back to an earlier point and re-work it or scan it if it was not available on the screen.

Finally, more students highlighted a text block without undertaking an editing action more often in the draft than the final session. The range of the use of this feature remained constant across writing sessions.

Use of menu-bar options. For utilization of options within the menu-bar, frequencies were relatively low, with one exception—formatting during the draft session. Given the nature of the task, a relatively low use of options, other than perhaps editing or spelling, might be expected. The non-use of macros is explainable in that students had not been introduced to them. Spell checking was used more frequently in the draft than final sessions. It should be noted that all students used the spelling feature at least once. The five students who did not check spelling during the draft stage did so at least once in the final session and the seven students who did not check their spelling during the final stage had done so at least once in the draft session.

A number of students clearly viewed the draft session as a time to set out format features (such as font style and size) which affected the visual presentation of their texts. More students did so more often in the draft session than in the final session. Indeed, when individual cases are examined, only one student increased in the use of this feature in the final session. That student used it once in the final session and not at all in the draft session. One other student did not use the format feature either in the draft or final sessions. All other users reduced their frequency of use of this feature, except one who used formatting two times in both draft and final sessions. Clearly, for most of the writers in the study, the decision on how their texts looked was one which they wanted to specify early in their writing.

Use of text deletion. Several trends emerged from the analysis of the frequency of use of specific modes of text deletion. First of all, backspacing appears to be the mode of choice. It is used more frequently in draft than in final sessions; however, even in final sessions it is used, on average, almost eleven times. The block-cut feature is used very infrequently across sessions. Indeed, only four students used it in the draft session or final sessions. One student used the block-cut feature in both sessions.

Frequency of text additions. When writing, students have two options available for the purpose of incrementing their texts. They may make insertions into previously written text or they may add to the end of their text (referred to as text entry).

The insertion strategy was used by all but one student. Even though fewer students used this strategy in the final session, the range of the frequency of its use was much wider in the final session.

Addition to the end of text (text entry) drops dramatically from the draft to final sessions. Eight of the ten students who did not add to the text in this manner revised their texts by using either block-cut, backspace-delete or insertion strategies. Of the nine students who saw the final session as an opportunity to add to their story, three did so very marginally (the frequency of use ranged from one to three occasions and the text amounts involved a few letters or words). The frequency of use of text entry for the remaining six students was between 13 and 47 and involved much larger text amounts. This pattern is at odds with that observed by Daiute (1986) who observed that students writing on computer tended to make additions to the end of their texts rather than within their texts. Although selective attrition limits the generalizability of the patterns noted in the present study, the patterns noted suggest that observation of the processes involved in the creation of texts on computers may yield different information than product analysis such as that of Daiute (1986).

Amount of text involved in keyboard actions

Table 3 summarizes the average amount of text involved per keyboard action. In interpreting these average scores, t-units were not converted into smaller units such as words or letters. This approach was taken to gain insight into the size of units typically involved in overt text scanning, text deletion, or text addition. For each individual keyboard action, the number of words, letters or t-units, as well as punctuation and spacing for selected actions, was coded and mean values were calculated.

Table 3

Amount of Text Involved per Keyboard Action (n=19)

Keyboard Action	Letter Mean	Letter Freq. of non-use	Letter Range	Word Mean	Word Freq. of non-use	Word Range	T-unit Mean	T-unit Freq. of non-use	T-unit Range
DRAFT									
Text scanning									
Backward cursor	1.73	7	0-3.29	4.39	2	0-13.6	0.47	11	0-2.14
Forward cursor	1.58	3	0-6	3.57	2	0-9.57	0.45	12	0-1.88
Backward mouse	1.03	10	0-3.5	5.59	8	0-14	1.08	11	0-7
Forward mouse	0.84	8	0-3	4.25	7	0-8.57	1	9	0-8
Block highlight	0.19	16	0-0.6	3.61	8	0-9.75	1.67	16	0-9.83
Text deletion									
Backspacing	1.34	0	.67-44	0.63	0	.3-4.2	0.07	14	0-21
Block deletion	0	19	0	1.1	15	0-5	1	17	0-9
Text addition									
Insertion	1.18	4	0-9.67	0.96	7	0-8.67	0.01	18	0-.14
Text entry	1.78	0	.76-2.5	4.7	0	1.4-9.4	0.16	18	0-.48
FINAL									
Text scanning									
Backward cursor	1.33	12	0-3	6.47	13	0-12	2.03	14	0-6.2
Forward cursor	1.87	9	0-6.33	4.44	10	0-7	1.11	13	0-3.5
Backward mouse	0.97	16	0-1.5	5.74	9	0-33	2.06	10	0-19
Forward mouse	0.95	9	0-3	9.71	4	0-25	1.18	7	0-11
Block highlight	0.88	16	0-3	4.53	14	0-13	0.35	16	0-1
Text deletion									
Backspacing	1.16	6	0-3.33	0.5	7	0-2	0.01	18	0-1
Block deletion	0	19	0	0.68	18	13	0	19	0
Text addition									
Insertion	0.58	9	0-3.33	0.81	10	0-3	0.03	17	0-.2
Text entry	1.99	12	0-3.67	4.5	12	0-7.06	0.01	13	0-.25

Table 3 (continued)

Amount of Text Involved per Keyboard Action (n=19)

Keyboard Action	Spacing			Punctuation		
	Mean	Freq. of non-use	Range	Mean	Freq. of non-use	Range
DRAFT						
Text scanning						
Backward cursor	—	—	—	—	—	—
Forward cursor	—	—	—	—	—	—
Backward mouse	—	—	—	—	—	—
Forward mouse	—	—	—	—	—	—
Block highlight	—	—	—	—	—	—
Text deletion						
Backspacing	0.01	16	0-.04	0.05	18	.04-29
Block deletion	—	—	—	—	—	—
Text addition						
Insertion	0.16	14	0-.88	0.12	10	0-1
Text entry	—	—	—	—	—	—
FINAL						
Text scanning						
Backward cursor	—	—	—	—	—	—
Forward cursor	—	—	—	—	—	—
Backward mouse	—	—	—	—	—	—
Forward mouse	—	—	—	—	—	—
Block highlight	—	—	—	—	—	—
Text deletion						
Backspacing	0.08	15	0-1	0.04	16	0-2.33
Block deletion	—	—	—	—	—	—
Text addition						
Insertion	0.08	14	0-.67	0.13	15	0-.5
Text entry	—	—	—	—	—	—

Text scanning. If keyboard actions are considered in terms of relative efficiency of use, it would seem logical to infer that back and forward space cursor movements are more appropriate for moving in small text increments while back and forward mouse or blocking movements are more appropriate for larger text increments. On average, students were working with relatively small text increments and scanned using multiple modes. When averages are compared, the modes in which t-units were more likely to be scanned were forward and backward mouse movements in both draft and final sessions as well as the forward cursor and block highlighting movements in the draft session. Students also scanned more words on average with the mouse. However, as Table 3 illustrates, students were quite variable in their patterns of non-use of each text element.

Text deletion. The average number of spaces deleted per keyboard action was quite low (0.01 in the draft and 0.08 in the final). Three students deleted spaces in the draft session and another four did so in the final session. The average number of punctuation marks deleted per keyboard action was also quite low (0.05 in the draft and 0.04 in the final). This might be expected because of the incidence rate of punctuation in relation to other features such as words or letters. Even so, it is surprising that few students used this editing feature. Only five students deleted punctuation using the backspace delete feature. Two did so in the draft session and three did so in the final session. One student deleted 29 punctuation marks; however, others deleted only a few. The student who deleted the 29 punctuation marks did so in the process of deleting a large block of text by using the backspace feature. For that student, there was a clear, but missed, opportunity to use a more advanced text-editing software-feature.

All students deleted letters and words using backspacing. However, backspace-deletion of large text increments such as t-units was undertaken by only six students. The average amounts of text involved in a backspace deletion were not very large—0.07 complete t-units, plus an additional 0.63 complete words and 1.34 letters in the draft session in comparison to .01 t-units, 0.50 words, and 1.16 letters in the final session. There was, of course, variability within a student's use of this strategy and among the students. Typically small units were the focus of the deletion action.

Block-cutting was a relatively infrequent strategy. The largest amount of text deleted using this feature was 6 words 11 t-units. The second largest was 7 t-units. The same student made both deletions which gave her an average block deletion pattern of 3 words 9 t-units. One other student deleted 6 words 1 t-unit. The two other students who used this feature used it on one to 13 words per keyboard action. While the low frequency of block-cutting for letter deletions is a positive sign in terms of efficient use of software features, the utilization of blocking to delete single words may indicate that students are not taking full advantage of the software features. Alternatively, it may also point to computer-editing as a process which is interrelated with the fluidity of the writing and which results in editing which is primarily of a micro-text nature.

Text additions. The utilization of text additions varied with the type of text being added. Few students used the insertion of spaces in revision. Of the five who did so in the draft session, three of them did so again in the final session. The average number of spaces added per keyboard action was minimal (0.16 in the draft and 0.08 in the final).

The insertion of punctuation was used by less than half the students in either their revision or their final sessions. In total, only eleven students inserted punctuation in either the draft or final sessions.

Even though the average number of punctuation marks entered per keyboard action was relatively small (0.12 in the draft and 0.13 in the final), it is notable that punctuation revision occurs more frequently, on average, in the insertion rather than the deletion mode. This may mean that for punctuation, at least, students are using a strategy which focuses on writing first and form later. However, because the average number of punctuation marks inserted appears similar in draft and final sessions, it appears that even with this text feature students are not bound by a conception that the final session is the session in which such revisions should be undertaken.

If the number of students inserting specific text units is examined, it would appear that fewer students insert larger chunks of texts. One student inserted two t-units while the other two inserted one-t-unit each. All other insertions were at the word or letter level. For the draft session, the average amount of text entered per keyboard action was 1.18 letters, 0.96 words and 0.01 t-units; in the final session it was 0.58 letters, 0.81 words and 0.03 t-units. The widest range is in the number of words entered. The general trend appears to be towards small-scale levels of text incrementation through the insertion strategy. Similar patterns are evident for the text entry category. However, the average number of words entered per keyboard action is much higher than the average number entered in the insertion mode. Even in regular text entry, though, very few students write in large text increments such as the t-unit. Instead, they proceed a few words at a time.

Individual student profiles

The way in which students use the computer for writing is likely a combination of their efficiency and effectiveness in using the technological advantages afforded by the machine, as well as their own personal style. Efficiency of use can be described as how quickly students use the features of the available software and hardware, while effectiveness of use can be described as the degree to which the features selected have been optimally and/or appropriately used. Finally, personal style may manifest itself most clearly in instances in which students have opted for alternate ways of using the technology which may not appear efficient and/or effective to the outside observer.

If examined by coding category, the data gathered using ScreenRecorder reveal a continuum of use and a preferential use of selected features for the sample group as a whole. But the grouped data analysis obscures important individual differences. Some students clearly used the computer in very unique ways. Three individual students are profiled here as exemplars of different styles of interaction with the computer.

Cathy: A relatively effectiv and efficient computer user. In examining the coding categories for the draft session, Cathy's name repeatedly could be found as either the most frequent user of a feature or among the most frequent users of a feature. Cathy was the student who used the block delete feature for 6 words 11 t-units and for seven t-units. However, she was also among the most frequent users of the backspace feature and, on average, used it for the largest amount of text (.67 letters, .51 words and .33 t-units per keyboard action).

Cathy moved around her text quite a bit, scanning it and shaping it. She was the highest user of forward cursor movements and the second highest user of backward cursor movements. She block highlighted text most often and did so for large chunks of text. She was the highest user of the forward mouse and, on average, covered the largest amounts of text with it.

Cathy was the second highest user of insertion as a strategy; however her use of this strategy was limited to letters and words. She was among those who continually incremented her text and she did so 47 times in the draft session. In other words, she began to write, then scanned or performed some other keyboard action, and then came back to where she left off on 47 different occasions.

Her use of the menu options seemed moderate in relation to others and appropriate given the nature of the computer task. She used the spelling menu on one occasion and the file menu twice. She fell into the mid-range in her use of the format option in that she used it 6 times.

Cathy's performance in the final session was different from that of the draft session in that she seemed to treat her text as pretty well completed and only worked on very minor areas. For instance, she never added to her text at all using text entry.

Although there are clearly areas in which Cathy's use of the computer mi become more efficient and effective, in comparison to the other students in the draft session, Cathy presented as a relatively efficient and effective user of the computer as a writing instrument. Her writing, when rated by teachers, fell into the mid-range.

Barbara: A low-tech user. A general description of Barbara during the draft session could be summed up in the phrase "Oh, it's a computer I'm using?!" Barbara either minimally used or did not use at all the technological advantages of the computer to assist her in her writing. The following represents the list of features for which Barbara's frequency of usage was zero: block highlighting, forward mouse movement, backward mouse movement, insertion, block-cutting, editing on the menu-bar, file on the menu-bar, format on the menu-bar, spelling on the menu-bar, page down, page up.

She used forward cursor movement seven times on small text increments, backward cursor movement five times on small text increments and she moved to the end of her text five times on small text increments. In terms of editing she used backspace delete primarily to edit single words. Yet she added to her text 24 times with and average entry per keyboard action of 1.38 letters, 6.67 words and 0.08 t-units. Although she tended to work in small text increments, this pattern is similar to many others in the sample. Barbara's papers were rated 5 on the six point scale. However, Barbara was unique in her underuse of computer features.

Jay: A graphics experimenter. In the draft session, Jay's writing seemed somewhat like Barbara's in that he did not use or minimally used many of the computer's features like block deleting, insertion, block highlighting, cursor movement, mouse movement, and movement to the beginning or end of his text. His preferred revision option was backspace delete. He fell just above the mean in terms of the frequency of text entry; however, the amount of text he entered was quite low. He entered text 43 times. The total amount of text entered across these times was 78 letters, 60 words and 2 t-units. The average amount of text he entered per keyboard action was 1.81 letters, 1.49 words and 0.05 t-units. His text was rated very low (1/2 on the six point scale) in the draft session and neared the average mark for the final session (3/3).

Despite his limited use of all of these features, Jay did use one feature more than any other student. He used the format feature of the menu-bar. He constantly returned to the format feature during the draft session and used it 16 times to experiment with the general layout and design of the small amount of writing he had done. As he began his writing he experimented with strings of letters which were non-words in order to play with formatting. In addition, he utilized a very stylized enlarged typestyle for his title.

In the final session, Jay's amount and frequency of writing fell into the high average range while all other features remained similar to the draft session with one exception—Jay did not use the format feature at all. Either he had satisfied himself with the visual display of his text or he decided that he needed to focus his attention elsewhere to get the task accomplished.

Discussion

Paper quality

When eighth grade students were given two similar expository writing tasks—one undertaken on the computer, the other off the computer—the work created using word processing was found to be significantly better in quality on each of the four scales on which it was rated: overall competence, focus, support, and mechanics. These results corroborate those of an earlier study by the present authors, in which the writing tasks used were narrative rather than expository. Both of these studies used student subjects with extensive prior experience in using word processing on a day to day basis in their schooling. As further research is undertaken with highly experienced students, it may become evident that the negative findings of some of the initial studies were an artifact of the subjects' relative lack of experience in word processing. Others (eg. Cochran-Smith, 1991) have pointed out that it may be necessary for students to have considerable practice in keyboarding and using the word processor's features if they are to develop enough facility with the tool to allow them direct their attention fully back to the writing process.

Given Haas' (1989) finding that advanced graphically-based word processors are more facilitative of good writing than older character-based systems, it is also plausible that the use of GUI word processing environments in this pair of studies contributed in some degree to their positive outcomes. Their relative simplicity and ease of use in comparison to command-key environments such as earlier versions of WordPerfect may make it possible for younger students to more effectively make use of their features, resulting in better writing.

Another factor that may have contributed to the production of better quality computer-written papers could be the relative level of student motivation for on and off computer composition. While the novelty effects of word processing would have long since passed into history, any of a number of the advantages of word processors such as the ease of editing, the elimination of onerous handwriting, and/or the higher quality of the printed text may have fostered greater motivation for the on-computer writing task, leading to higher quality work in this medium.

The fact that students at all levels of language arts achievement showed similar levels of writing quality gain when using word processors has both theoretical and practical significance. It lends support to the position that word processing can have broad application in the junior and intermediate panels and that it can be usefully employed by students regardless of their current achievement levels. At the theoretical level, it argues against the position of those scholars (c.f. Cochran-Smith, 1991) who hold that only those students already making use of mature editing and revising strategies are likely to show improvements in their writing when they begin to compose at the keyboard rather than by hand. Our process study results suggest that writers with immature revising practices may make use of a smaller set of the word processor's capabilities than their more skilled peers; nevertheless these students still benefit from access to word processing, perhaps in part because it facilitates the types of editing they routinely employ.

Interestingly, there was no difference in the average length of the papers written in the two conditions, possibly because of the more tightly specified nature of the task as compared to our earlier study and the source materials used. The equivalence in length eliminates the possibility that the higher ratings given to the word processed essays were an artifact of their greater length, as Daiute (1986) suggested was the case in her study.

The composing process

The composing patterns observed using ScreenRecorder offer some interesting insights into student use of word processors as writing tools; however, the attrition rate in the present study does limit the generalizability of the findings. The process analysis results highlight the utility of this form of data collection software and point in several directions in terms of future exploration. For example, the patterns observed suggest that students are using the computer as a writing tool in much the same way as the experienced writers described by Lutz (1987)—that is, they seem to be writing and revising in small increments. Even though the draft and final sessions differ in terms of some uses of the computer, revision occurred across both sessions. For some users, much more revision occurs during the so-called "draft" session. Greater amounts of text scanning, as indicated by movements of the cursor by both the cursor keys and the mouse, occurred during the initial drafting session. This may be indicative of a higher degree of checking and rereading during a phase in which students see the text as highly tentative and malleable. As well, students highlighted blocks of text without altering or moving them more frequently during the initial text creation session than they did during revision. The fact that this feature was activated without some subsequent action being taken is open to a number of explanations: (a) students were indecisive about their intentions until the highlighting allowed them to focus and think through the possible options, (b) they hadn't yet come to trust their ability to use the text moving feature; or (c) they had inadvertently blocked the text. It will be recalled that spell checking was used more frequently in the draft than final sessions. This pattern seems to be in opposition to descriptions offered by scholars in the field of writing who have studied handwritten composition. They see spelling as featuring more prominently in the editing and finalization stages whereas the drafting stages focus on meaning (e.g., Graves, 1983).

As mentioned earlier, more students set out the format features of their text during initial creation than in the revision session. A number of explanations seem plausible for this behaviour: (a) Because the Macintosh screen displays the text as it will be printed (unlike other computers in which the screen display remains in a single font style and size regardless of the font selected for printing), students may decide to use a specific font in the same way that they decide to either print or cursively write a handwritten text. (b) The experimentation with font styles and sizes may simply reflect "procedural display" (Bloome, 1987) on the part of the students—that is, the students are trying to give the appearance that they are engaged in productive work. While the students were experimenting with the font styles, they would appear to others to be engaged in the composing process and their actions would be observably similar to peers who were composing. It is possible that students may be engaging in this behaviour simply to delay the writing task. (c) Certain fonts may be more appropriate for some audiences than others. Since students knew that their texts were to be sent either to a government official or to the president of a large oil company, they may have wanted to select a particular font early to establish a certain visual tone. Nevertheless, once again, the refinement of the graphic display (if interpreted as non-semantic in nature), has been another element which writing experts (e.g., Graves, 1983) suggest students leave until the final editing; however, it must be noted that these experts have typically been involved in studying handwritten text production.

More importantly, fewer students using word processing chose to insert new text into previously written material during the final session than did in the drafting session, and very few added new text to the end of their compositions in the final session. Text deletion, as well, was more common in the drafting session than in the revision session. When these outcomes are considered in conjunction with the findings already discussed regarding text scanning, spell checking, and formatting, they suggest that the labels "draft" and "final" are misleading, since writing on computers seems to foster an ongoing and iterative process of revision of previously written material. The labeling of computer writing sessions as draft and final would seem to be, in part, an artifact of the application of concepts derived from the observation of handwritten composition which, by its very nature, forces much of any analysis into an analysis of written products which fit more easily into "draft" and "final" categories.

Despite students' ability to use the block cutting and pasting features of Microsoft Works for editing as indicated by the editing test, few chose to make use of it in either session when writing on computer. Several explanations for this lack of use seem plausible. First of all, the students may not have trusted the block editing procedure or their mastery of it. Secondly, the amount of text involved in the action may have influenced the keyboard action selected. Most student text deletions were quite short, and many students may have decided (appropriately enough) that short deletions were more efficiently carried out using the delete key. What the lack of macrostructural editing and revision itself can be attributed to is not clear. It may result from a lack of instruction in the appropriate revision skills. Alternatively, it may be that no additional instruction would prompt greater macro-level revision, either because students were not yet at a point in their cognitive development where they could effectively master such skills, or because of the shorter and less complex nature of compositions produced by students at that age level they were largely unneeded—students were able (or thought they were able) to "get it right the first time". (Judging from the relatively mediocre focus ratings of both on and off computer papers, the latter was far more likely.) Finally, there is the often-overlooked element of motivation. While every effort was made to provide students with a sense of purpose and audience for the assignme and observation indicated that the great majority of students pursued their work conscientiously, for reasons of experimental control the topics used were not of their own choosing, which could have reduced their motivation to make the effort required for macro-level revision.

Conclusion

Together with our previous study, our present research suggests that word processing can make a modest but nonetheless significant difference in the quality of student writing in both the narrative and expository genres once students have acquired extensive experience writing with the computer, over and above any benefit from such experience that may have generalized to handwritten composition. The precise causal mechanisms are still not clear; but it seems likely that the editing capabilities and ease of use of the advanced word processing environment employed in our research facilitated their microstructural editing and promoted a more iterative writing process, resulting in the production of better quality work. It is also probable that the process was mediated by students' motivational considerations which favoured word processing over hand writing. More analysis of the revision processes revealed in the handwritten work is currently being undertaken to develop a clearer understanding of the role of revision in promoting writing quality.

The collection of ScreenRecorder tapes allowed the research team to see that many students make use of the editing and formatting features of the computer software, and that some use those features less effectively than others. It also revealed the importance of individual differences. As Cochran-Smith and others have suggested (Cochran-Smith, 1991), students appear to bring their own personal style of working to the word processing environment; computers do not of themselves dramatically change student writing style. Instead they appear to facilitate whatever level of editing the user wishes to engage in. For some writers, like Barbara, the computer may not make too much of a difference to their writing. For others, like Jay, the computer's capabilities may actually take away from the writing event given an interfering interest in graphics. Yet, for writers like Cathy, the use of the computer as a writing tool may meld in a way that allows the strengths of the tool to be utilized and a moderately successful writing piece to emerge. Still, the results of the present study suggest that writers at all levels of language arts achievement typically show equal degrees of improvement in their writing when working on computer. This holds true even for those students whose observed on-computer editing and revising strategies are very limited. An important question not addressed here is whether very long-term use of the computer for writing could gradually facilitate deeper transformations of the writing process. Longitudinal studies of several years' duration will be required to find the answer.

The observed patterns of revision suggest that the computer allows for an evolutionary text. Because of the writing options the computer enables, it may be that different descriptors for revision are necessary. Revisions may need to be analyzed in a way that includes the interaction of the tool and the written text. Using systems of analysis derived from product analysis alone is insufficient. Process analysis, think-aloud protocols, and student perceptions of their own efficiency and effectiveness on and off the computer need to be added to future data collection projects in order to understand the multifaceted nature of the writing task.

Several areas of the ScreenRecorder data which have yet to be explored include how the spelling checker feature is used. It is possible that the patterns of its use will assist in explaining why students who write on computers make different types of spelling errors than those who write off computers (Owston, Murphy, & Wideman, 1990). In addition, a detailed macrostructural and semantic analysis of the texts written on and off the computer should provide additional insights into computer writing. Both these studies are currently underway. Work is also beginning on the development and application of these coding systems to the ScreenRecorder data. Through such efforts, not only can a detailed understanding of computer writing be articulated, but, perhaps we can broaden our understandings of the relationships between human communicative processes and the tools used for such communication.

References

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition.* Hillsdale, NJ: Lawrence Erlbaum.

Bernhardt, S. A., Wojahn, P., & Edwards, P. (1988, March). *Teaching college composition with computers: A program evaluation study.* Paper presented at the Meeting of the Conference on College Composition and Communication, St. Louis, MO. (ERIC Document Reproduction Service No. ED 295 191)

Bloome, D. (1987). Reading as a social process in a middle school classroom. In D. Bloome (Ed.), *Literacy and schooling.* Norwood, NJ: Ablex Publishing.

Britten, R. M. (1988). The effects of instruction on keyboarding skills in Grade 2. *Educational Technology, 28*(4), 34-37.

Broderick, C., & Trushell, J. (1985). Word processing in the primary classroom. In J. Ewing (Ed.), *Reading and the new technologies* (pp. 119-128). London: Heinemann.

Bruce, B., Michaels, S., & Watson-Gegeo, K. 1985). How computers can change the writing process. *Language Arts, 62*, 143-149.

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

Cochran-Smith, M., Paris, C.L., & Kahn, J. (1991). *Learning to write differently.* Norwood, NJ: Ablex.

Collier, R. M. (1983). The word processor and revision strategies. *College Composition and Communication, 34*, 149-155.

Daiute, C. (1986). Physical and cognitive factors in revising: Insights from studies with computers. *Research in the Teaching of English, 20*, 141-159.

Dalton, B. M., Morocco, C. C., & Neale, A. E. (1988, April). *"I've lost my story!": Integrating word processing with writing instruction.* Paper presented at the meeting of the American Educational Research Association, New Orleans. (ERIC Document Reproduction Service No. ED 296 717)

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

Dickenson, D. K. (1986). Cooperation, collaboration, and a computer: Integrating a computer into a first-second grade writing program. *Research in the Teaching of English, 20*, 357-378.

Engberg, R. (1983). I'll write, just lead me to my computer. *Classroom Computer Learning, 4*(2), 68-69.

Faigley, L., & Witte, F. (1981). Analyzing revision. *College Composition and Communication, 32*, 400-414.

Fisher, G. (1983). Word processing: Will it make all kids love to write? *Instructor, 152*(6), 87-88.

Flinn, J. (1985). *Composing, computers, and contents: Case studies of revising among sixth graders in national writing project classrooms*. Unpublished doctoral dissertation, University of Missouri, St. Louis.

Graves, D. (1983). *Writing: Teachers and children at work.* Portsmouth, NH: Heinemann.

Haas, C. (1989). Does the medium make a difference? Two studies of writing with pen and paper and with computers. *Human—Computer Interaction, 4*, 149-169.

Hasan, R. (1984). Coherence and cohesive harmony. In J. Flood (Ed.), *Understanding reading comprehension*. (pp 181-219). Newark, Deleware: International Reading Association.

Hawisher, G. (1986). Studies in wordprocessing. *Computers and Composition, 4*, 6-31.

Hawisher, G. E. (1987). The effects of word processing on the revision strategies of college freshmen. *Research in the Teaching of English, 21*, 145-159.

Hawisher, G. E. (1989). Research and recommendations for computers and composition. In Hawisher, G. E., & Selfe, C.L. (Eds.), *Critical perspectives on computers and composition instruction* (pp. 44-69). New York: Teachers College Press.

Hooper, S. C. (1987). *Using word processors in high school and college writing instruction: A critical review of current literature.* Unpublished manuscript, Calvert Hall College Prep High School, MD. (ERIC Document Reproduction Service No. ED 286 203).

Hult, C. A. (1986, March). *The computer and the inexperienced writer.* Paper presented at the meeting of The Conference on College Composition and Communication, New Orleans. (ERIC Document Reproduction Service No. ED 271 772)

Hunt, K. (1965). *Grammatical structures written at three grade levels.* Urbana, IL: National Council of Teachers of English.

Joram, E., Woodruff, E., Lindsey, P., & Bryson, M. (1990). Students' editing skills and attitudes towards word processing. *Computers and Composition, 7*(3), 55-72.

Kahn, J. (1988). *Learning to write with a new tool: A study of emergent writers using word processing.* Unpublished doctoral dissertation, University of Pennsylvania.

Kane, J. (1983). *Computers for composing* (Tech. Rep. No. 21). New York: Bank St. College of Education.

Kurth, R. J. (1987). Using word processing to enhance revision strategies during student writing activities. *Educational Technology, 27*(1), 13-19.

Larter, S. (1987). *Writing with microcomputers in the elementary grades: Process, roles, attitudes, and products.* Toronto: Queen's Printer.

Lutz, J.A. (1987). A study of professional and experienced writers revising and editing at the computer and with pen and paper. *Research on the Teaching of English, 21*, 398-421.

MacArthur, C. A. (1988). The impact of computers on the writing process. *Exceptional Children, 54*, 536-542.

Moore, M. A. (1987). The effect of word processing technology in a developmental writing program on writing quality, attitude toward composing, and revision strategies of fourth and fifth grade students. (Doctoral dissertation, University of South Florida). *Dissertation Abstracts International, 48,* 635A.

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

Myers, M. (1980). *A procedure for writing assessment and holistic scoring.*Urbana, Il: ERIC Clearinghouse on Reading and Communication Skills and the National Council of Teachers of English.

Owston, R.D., Murphy, S., & Wideman, H.H. (1990). *On and off computer writing of eighth grade students experienced in word processing* (Tech. Rep. No. 90-1). North York: Centre for the Study of Computers in Education, York University.

Owston, R.D., Murphy, S., & Wideman, H.H. (1991a, April). *Computers in the writing process: A study and its replication.* Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Owston, R.D., Murphy, S., & Wideman, H.H. (1991b). On and off computer writing of eighth grade students experienced in word processing. *Computers in the Schools, 8*(4).

Pea, R. D. & Kurland, D. M. (1989). Cognitive technologies for writing. *Review of Research in Education, 14,* 277-326.

Pearson, H., & Wilkinson, A. (1986). The use of the word processor in assisting children's writing development. *Educational Review, 38,* 169-187.

Quellmalz, E. (1981). *Scale for Evaluating Narrative Writing.* (ERIC Document Reproduction Service No. ED 236 653)

Quellmalz, E. (1982). *Scale for Evaluating Expository Writing.* (ERIC Documentation Reproduction Service No. ED 236 670)

Rodrigues, D. (1985). Computers and basic writers. *College Composition and Communication, 36,* 336-339.

ScreenRecorder. (1988). Berkeley, CA: Farallon Computing.

Sommers, N. (1980). Revision strategies of student writers and experienced adult writers. *College Composition and Communication, 31,* 378-388.

Teichman, M., & Poris, M. (1989). Initial effects of word processing on writing quality and writing anxiety of freshman writers. *Computers and the Humanities, 23,* 93-103.

Wilde, S. (1989). *Looking at invented spelling: A kidwatcher's guide to spelling, part 1.* In K. S. Goodman, Y. M. Goodman & W. J. Hood (Eds.), The whole language evaluation book (pp. 213-226). Portsmouth, NH: Heinemann.

Wolf, D. P. (1985). Flexible texts: Computer editing in the study of writing. In E. Klein (Ed.), *Children and computers* (pp. 37-54). San Francisco: Jossey-Bass.

Woolley, W. C. (1985). The effects of word processing on the writing of selected fifth-grade students. (Doctoral dissertation, The College of William and Mary). *Dissertation Abstracts International, 47,* 82A.

Appendix A

Word Processing Skills Test

The Big Race

By a Grade 8 student

It was the day of the big race at Sam Sherratt Mark Get Set ...BANG. We were off - I could the feel the wind against my hair and I ran faster, faster and faster. I felt like I was runnning on air, my hair stood out straight and my eyes started to water. Then It happened, I looked down and I saw the race beneath me. I ran and ran, further and further. I saw the stars pass by me.

I stared straight ahead and the earth was infront of me, then it came to me, I was running around the world. Then I started dropping faster and faster. I could feel the gravity pull me through the atmosphere getting closer to the ground by the second. I started to see the race then I hit the ground. I looked behind me and saw all the other contestants, they were still behind me running their fastest. I had won the race! Everyone crowded me and said that I ran so fast that I was just a blur in their eyes. That's when I said, "I felt like I ran around the world" and I claimed my trophy.

1. Delete text - ask students to select the word "big" in the first sentence and then delete it.
2. Insert text - insert the word "huge" where big used to be.
3. Cut and paste - select the entire first sentence, cut it, and paste it after the word "BANG".
4. Spell check -
   - "Sherratt" (skip the word)
   - "runnning" (choose correct word from dictionary)
   - "infront" (view selections and select)

N.B. QUIT THE PROGRAM BUT DO NOT SAVE CHANGES!

Appendix B

Writing Assignments

Teacher Directions for Writing Assignment - Draft Papers

"We are going to write a position paper about:

A. the Hagersville tire fire and its effects on the environment
B. oil spills and their effects on the environment

When you finish I'll put all of the papers together and I'll send them with a covering letter to:

A. The Minister of Environment
B. The President of Exxon Oil Company"

"First of all do you remember what a position paper is?" (Clarify with the students what a position paper is.)

"Around the class are pictures to remind you of the kind of damages these disasters can causes. What do you think are the important issues that you should include in your paper?"

(Ask students to brainstorm and write their answers on the board; then ask students to jot down some more issues on their own.)

"Now begin writing your paper. Be sure to say what the problem is, why you think it is wrong, and what should be done about it. Discuss your ideas first with a partner and write a draft of your paper today. Next class you will have time to revise your paper."

Teacher Directions for Writing Assignment - Final Papers

"Last class you began writing a paper about:

A. the Hagersville tire fire
B. oil spills"

"Now discuss your draft with your partner. Make any revisions that you feel are necessary." (For computer work only: "Remember that when you are revising you can move blocks of text. We showed you how to do this before.")

"Proofread your paper carefully because I am sending it to the Minister of Environment (President of Exxon) Use the spellchecker (on the computer) and the dictionary (in classroom) if you need to. I will be collecting your work at the end of this class."

Student Writing Assignment

(Teacher to write on board)

Write a position paper about:

A. the Hagersville tire fire
B. oil spills

and its/their effects on the environment. In your paper make sure to discuss what you think the problem is, why you think it's wrong, and what can be done about it.

Appendix C

Summary of *Scale for Evaluating Expository Writing*

(Quellmalz, 1982)

General Competence

Level 6	Excellent example
Level 5	Good
Level 4	Adequate
Level 3	Developing
Level 2	Rudimentary
Level 1	Off topic, off genre

Focus/Organization

Level 6	subject clear; main idea clear; key points, reasoning at beginning or end; beginning and end relate; plan logical; plan signaled by transitions; paragraphs set off *all* major ideas; no digressions
Level 5	subject clear; main idea clear; topic *partly* limited by reference to number or type of key reasons; logical plan; *some* transitions; *most* major ideas in paragraphs; *minor* digression
Level 4	subject clear; main idea clear; topic *may* be limited; plan logical, but sub topic can be reshuffled; many major thoughts in paragraphs; few minor digressions, no major
Level 3	subject clear; main idea *not very* clear; plan attempted, must *infer; some* logically developed paragraphs; some major digressions or excessive elaboration
Level 2	subject clear; main idea *not very* clear *or* more than one; plan attempted; few paragraphs logically developed; many digressions
Level 1	subject may be unclear; main idea unclear; plan unclear; almost no logically developed paragraphs

Support

Level 6	main idea and *all* major topics elaborated by more specific details; enumerations supported by detail, function, rationale
Level 5	almost all major points elaborated by more specific detail, elaboration; most elaboration is specific
Level 4	many major points supported; much elaboration is specific
Level 3	some major points developed by elaborative detail and reasons; some elaboration is specific but is distinct and clear; may be a list
Level 2	supportive detail attempted; may be redundant; may not be precise or clear
Level 1	little or no support *or;* support is confusing or at the same level of generality as the main assertion

Mechanics

Level 6	one or two minor errors, no gross errors
Level 5	a *few* minor errors; may be one gross error; usage and mechanics still not a problem
Level 4	a few common errors; one or two gross plus no more than one minor
Level 3	some errors interfere; some gross and minor; sentence construction below mastery
Level 2	many gross and minor; some confusion
Level 1	difficult to read; many gross varied; very confusing

Appendix D

Sample Student Papers

Paper A

General Competence	6
Focus/Organization	6
Support	6
Mechanics	5

TIRE FIRE

It all started on February, 12th, 1990. An event had taken place that would change the future of the city Hagersville and many others. A land of twenty acres with fourteen million tires, caught on fire. It was said to be arson. Today, February, 28th, and the fire has not yet been controlled. There are still tires burning and more problems are occurring due to the length of the fire.

There are many ways this fire in Hagersville could have been prevented. Was it the mistake of Ed Straza, the owner of these burning tires? In my opinion, he shouldn't of left these tires under no supervision and no protection. It was a lack of responsibilities that could have been the cause of this disaster. These tires should have been recycled. It was also the mistake of the Government, in being so slow in giving Mr. Straza the grant to get these tires recycled to make new products. As you know it is an expensive procedure in recycling so many tires.

A point which I feel should be made is the consequence of this tragedy. For one thing it is much more expensive to repair the damage made from the fire than it would have been in recycling those fourteen million tires.

Pollution is also another effect we should look at. The fumes from the tires are harmful to the wild-life and also to people. Homes, properties and businesses are all forced out of their buildings. Someone's business could very well be put out of work and properties are damaged severely.

The water supply is also important. The oil that is seeping into the ground is getting into our drinking water which is very dangerous and could make people and also animals ill.

The fire is a lesson for other people who own tire dumps such as Ed Stratza. They should now be aware of the problems which could take place because of the irresponsibilities in leaving so many tires out in an open field. The Government should also now be alert of the consequences. I think this fire could have been prevented if the Government would have recycled the tires, instead they waited too long and let the fire take place.

Now, us as citizens should volunteer in helping clean this mess up. However, it will not be the end of our problem. We all have to take the initiative and prevent this disaster from ever happening again.

Paper B

General Competence	5
Focus/Organization	5
Support	5
Mechanics	6

Oil and the Effects on our Environment

On March twenty fourth in Prince William Sound, there was an oil spill. A ship called Exxon Valdez was carrying thirty-eight million litres of oil. The ship hit bottom and broke open. All the oil came spilling out lining 1000 miles of coastline with an oily scum.

I think that the problem is our wild life. The fish and birds in the waters were covered with oil. Some of the birds were saved by being bathed to get the oil of their feathers but others were not as fortunate and died. Without fish there would be a lot of people out of work. Some of those people would be fishermen. They would not have any fish to catch and would not make any money to support themselves and there families. If some of the fishermen did catch some fish that had been covered with oil the fish could eventually end up on our plates and cause serious damage to our health.

I think that the ships should have separate containers to hold the oil so that if the ship does get broken than the oil will not spill out because it will be in a different container. If the ship does not have a separate container than the ship should not be allowed to sail in the water. If a ship does sail without this than the captain or who ever is involved should be fined.

This situation effects everyone and everything around us and should not be ignored any longer.

Paper C

General Competence	4
Focus/Organization	3
Support	4
Mechanics	3

HAGERSVILLE TIRE FIRE

It started February12 1990 at 1 o'clock in the morning , it has now been burning 16 days. Volunteer fire fighters our working around the clock, 24 hours a day everyday since it started.

Why should it take a huge tire fire whitch had 14 million tires and covered 20 acres to make the government to check all the big places with tires. Think of what could of happened if it had seeked into the water table. A lot of the water in that area whoud have been contamunated. As it is the people in the nabour hood who want to sell there house might have a hard time selling because that market value in that area must have dropped.

For every tire that is bought there is five dollars sales tax , that money is supposted to go to the government so that they can recycle thoose tires when they have worn out. 14 million tires multiplied by 5 dollars for recycling equals 70 million dollars that wasn't wasn't even used. It makes you wounder what they did use that money for? or what they are using the other money from the other billions of tires that were bought and stored somewere else.

I hope that the government wakes up and smell the coffee so to speak, and dosn't just leave tires sitting around so another tire can start.

Paper D

General Competence	3
Focus/Organization	3
Support	3
Mechanics	3

Oil Spills

The problem with oil spills are that they take so long & take so much money to clean up. Plus all of the wild life to save. Although hundreds are saved thousands die. Did you know it costs over $30 000 to clean each sea otter. That is alot of money to pay for a problem that could have been prevented.

As you know there is a controversy right now concerning the Exyon Valdez & her Captain Joseph Hazelwood; the estimated cost to clean up is $1-$200 000 000. Again that is alot of money to pay for a problem that could be prevented

The Captain, Hazelwood was drunk, at the time of the spill & the under skilled skipper was steering. I think that the whole ship's crew should be trand to be able to steer the ship in an emer-gency

The ship was unskillfully steered in to a hazerdeous reef where 38,000,000 liters of oil spilled into the icy Alaskan watters of Prince Will. Sound

Right now we can do nothing but wait for the word on how we must clean it up. And now almost a year after this trag :ty occured the mess still isn't cleaned up.

Some questions that need to be answered are.

Who is going to pay for this?

Why are these problems happening?

What can we do?

What will happen to the wildlife?

and

What are one methods of clean up?

Paper E

General Competence	2
Focus/Organization	3
Support	2
Mechanics	5

OIL AND THE EFFECTS ON OUR ENVIRONMENT

I think the problem is because of the oil spill one animal is going to get sick and then eventually we are going to get sick and MAYBE die. Also the spill will not be very help full to the company that ships it. The beaches will be covered in oil and that means that there will not be a lot of tourists. Another problem is that it will cost a lot to clean the mess up because they have to hire people to clean and buy the equipment.

We need the oil so if the tankers keep getting holes in them then the government might shut down the company and we will not get our oil. That causes a problem for us because we need the oil to run our cars and heat our houses.

We do not need the tankers because we can set up pipe lines that go all over the world.

Paper F

General Competence	1
Focus/Organization	1
Support	1
Mechanics	1

Hagersville Blaze

Dear Ministry of Enviroment

I am writing to you to share my fellings about the Hagersville tire blaze . Ever since Febuary 12 , 30 volunteer firemen battling the blaze.

The Centre for the Study of Computers in Education is dedicated to encouraging collaborative research between schools, industry, government, and the university. Inquiries may be directed to: Centre for the Study of Computers in Education, Faculty of Education, York University, 4700 Keele St., North York, ON, M3J 1P3