The Effects of Word Processing on Students' Writing Quality and Revision Strategies

Ronald D. Owston
Sharon Murphy
Herbert H. Wideman
York University

This study examines the influence of word processing on the writing quality and revision strategies of eighth-grade students who were experienced computer users. Students were asked to compose two expository papers on similar topics, one paper using the computer and the other by hand, in a counterbalanced repeated measures research design. When students were writing on the computer, "electronic videos" were taken of a subsample of students using an unobtrusive screen-recording software utility that provided running accounts of all actions taken on the computer.

Papers written on computer were rated significantly higher by trained raters on all four dimensions of a holistic/analytic writing assessment scale. Analysis of the screen recording data revealed that students were more apt to make microstructural rather than macrostructural changes to their work and that they continuously revised at all stages of their writing (although most revision took place at the initial drafting stage). While the reason for the higher ratings of the computer-written papers was not entirely clear, student experience in writing with computers and the facilitative environment provided by the computer graphical interface were considered to be mediating factors.

As the use of word processing in student writing becomes increasingly commonplace, the need to understand its impact on the processes and products of composition is made more pressing. Certainly the considerable body of anecdotal reportage on the positive effects of word processing on students' writing and revision has helped fuel the use of computers in composition (Bernhardt, Wojahn, & Edwards, 1988; Collier, 1983; Engberg, 1983; Fisher, 1983; Rodrigues, 1985). A number of arguments, some having considerable plausibility, have been articulated to support the contention that certain features and capabilities of word-processing environments can facilitate writing and revising. There is some evidence that the work of rewriting by hand may be a serious impediment to revising (Daiute, 1986). It has been suggested that by eliminating the drudgery of recopying a composition and by allowing for far easier text modification, the use of 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). The critical issue is whether the relative ease of revision that the computer makes possible leads students to autonomously develop the more mature writing and revision practices characteristic of adult writers. Will the technology enable students to move from the surface level editing of spelling and syntactical errors typical of novice writers to revision at the sentence and paragraph level that focuses on the substance and form of the text, the type of revision that is engaged in extensively by accomplished authors (e.g., Bereiter & Scardamalia, 1987; Sommers, 1980)?

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 and personally valuable form of communication in which the student can take pride (Bruce, Michaels, & Watson-Gegeo, 1985; MacArthur, 1988).

Arguments against the use of word processing have also been offered. 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 elimination of recopying, and thus rereading tasks, 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 (e.g., 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 that require the use of a complex sequence of cursor and command-key sequences for block editing are used. Even the lack of typing skills may interfere with higher order processes involved in composing, adversely affecting students' writing (MacArthur, 1988). One study suggested that poor typing ability can distract students from their writing tasks (Dalton, Morocco, & Neale, 1988).

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 recent reviews of the literature, both Hawisher (1989) and Cochran-Smith (1991) concluded that texts tend to be longer when written on a computer, and the finished products contain 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, Wojahn, & Edwards, 1988; Sommers, 1980; Teichman & Poris, 1989). When pre-college students are used as subjects, the results are more contradictory. Cochran-Smith contended in her review that "word processing, in and of itself, does not improve the overall quality of students' writing" (1991, p. 114). But such an assessment may be premature. In several multi-class experiments with junior and intermediate level students, word-processed compositions were rated higher than handwritten papers (e.g., Dalton & Hannafin, 1987; Moore, 1987; Owston, Murphy, & Wideman, 1991). Because so few adequately designed studies have been undertaken with younger students, it is too early for broad generalizations about the impact of word processing on writing quality.

As to its impact on students' editing and revising practices, the findings of several recent studies suggest that the pre-existent levels of editing and revising skill that 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 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 (e.g., Kane, 1983; Wolf, 1985; Hill, Wallace, & Haas, 1991). 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 (e.g., Broderick & Trushell, 1985; Pearson & Wilkinson, 1986).

Moore (1987), for example, found that students using word processing made more meaning-related changes in text than did those using pen and paper. But there are indications that some novice writers may not have the capability to utilize the potential benefits the computer brings to the writing process until they are taught how to edit and revise effectively. Evans (1986) looked at the use of word processing in two contrasting junior-level classes—a process writing class in which editing was taught and a skills writing class in which it was not. 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 produce more meaningful editing and revising. Flinn (1985) and Kahn (1988) (cited in Cochran-Smith, 1991) found that word processing can improve the quality of revision over that in handwritten work but that the nature of the revisions undertaken reflects the types of editing and revision practices taught in the ongoing writing instruction.

Limitations of Recent Studies

Unfortunately, there are serious weaknesses in many of the extant studies of word processing that make interpretation of their findings problematic. The majority of these investigations took place over a relatively short period of time using students who had at best very limited prior experience with word processing (Hawisher, 1989). Given the likelihood that a lack of facility with keyboarding and editing procedures may reduce students' attention to the substantive nature of their composing and revising, it is questionable whether very short term practice in on-computer composition can be expected to have a significant impact on the quality of student writing and the extent of revision activities. And most of the research does not address what is perhaps the most salient issue—the longer-term effects of extensive on-computer writing on process and product. As suggested earlier, it may be 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.

Many of the currently available studies fail to provide critical contextual information needed to meaningfully interpret their results. Levels of student competence in keyboarding and editing procedure (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 compositional pedagogy, making it impossible to determine the influence of instructional factors on the reported outcomes.

An important limitation to many of the current studies lies in the nature of the word-processing software used, which has nearly always 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 character-based versions of WordPerfect or Bank St. Writer, for example. The GUI writing tools have the added advantage of display veracity (boldface appears bold, etc.) and can readily incorporate graphics elements, two display features which may strongly appeal to younger students. A study by Haas (1989) found that writers using advanced workstations with GUI word processors and mice produced longer texts than those working with character-based text editors on regular PCs and that the writing quality was significantly higher.

Finally, very few investigations to date have offered any detailed analysis of the forms of the editing and revision practices students employ in their writing when using word processing 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 printed draft and final versions of the document, critical elements of the editing and revising process which occur at the point of utterance (as text is being keyed in) are probably being lost to analysis. There is considerable 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 examined how writing with word processing influenced both the composition process and the quality of work produced by eighth-grade students engaged in one type of writing task. The design used transcends many of the limitations common to prior work discussed in the previous section. It addresses two questions: Do intermediate-level students who are 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 working with paper and pencil? And what is the nature of the revision process as it is engaged in by these students when working on computers? The study builds on an earlier work in which the effects of word processing on narrative composition were examined using a similar design (Owston, Murphy, & Wideman 1991). In that research, it was found that stories written with the aid of a word processor which were scored on four dimensions using a holistic/analytic scale were significantly better than hand-written stories in their overall quality and exhibited greater evidence of writing competence and mechanical fluency. In both the earlier and the present study, the student subjects 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 to examine some of the intermediate-term effects of word processing on the writing of students who were relatively comfortable with the word-processing environment.

The effect of word processing on revision processes is also explored in some detail in the study reported here. A real-time screen-recording utility was employed which made it possible to capture all occurrences of text revision, including those undertaken at the point of utterance. With these data it was possible to undertake a detailed categorical analysis of all editing and revision activities engaged in by a sample of students.

Method

Subjects

Four classes of eighth-grade students (n = 111) from a K-8 public school in which computer use had been extensively integrated 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 over a year and a half prior to the start of the research. During these periods, students had unrestricted access to their own Macintosh computers.

Two teachers each taught communication arts to two of the classes. Both teachers had been using a variant of the process approach to the teaching of writing. The study commenced about two-thirds of the way through the school year. By that time the first teacher had assigned about 12 writing tasks to her students, most involving narrative composition. This teacher employed a consistent pedagogy in her teaching of writing. A theme or topic was introduced through the presentation and discussion of thematic materials, and group prewriting activities were undertaken. Students would then work individually on a draft composition on the assigned topic. All student writing was done on Macintosh computers using Microsoft Works software, a program which includes a fairly simple word processor that supports mouse-based editing and makes use of a drop-down menu interface for file manipulation and formatting. Draft papers 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 to address issues of content, coherence, and style as needed. The student then made the agreed-upon modifications in the text file using the editing capabilities of the word processor, and final versions of the compositions were then printed for inclusion in the students' writing folder or display on the classroom walls.

The second teacher's writing curriculum diverged from the first teacher's in several respects. This teacher had his students write proportionally more descriptive and expository compositions and fewer narratives. The 15 papers that his students had written by the time the study began were equally divided among these three types. Because the second teacher taught science in addition to communication arts, he would sometimes integrate his writing assignments into current science units (which the first teacher did not do). Within a writing topic area, his students were given some leeway in choosing aspects of the topic to write about that drew on their own interests and knowledge. He used a similar process pedagogy to the first teacher's, but he would hold conferences with students about their drafts only when he felt there was a need for it; therefore, his students did not always discuss their drafts with him. He also more often pointed out errors in spelling and grammar observed on a student's screen during the drafting process than did the first teacher (who would usually wait to see if the peer editing sessions would attend to these problems).

Pretesting

The students' facility with the word-processing module of Microsoft Works was pretested by having all classes edit a simple test document file which contained several errors. The test required students to correct the errors, to use the program's spelling checker, and to move a block of text from one location in the document to another. As students worked on the task in the computer lab, their level of mastery was assessed by several observers. All of the students appeared able to key in words at a reasonable speed—equivalent to that of 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 spellchecker effectively and knew how to move a text block to a new location by using the mouse to select text and menu commands to cut and paste. Individual instruction was provided to the few students who were initially unable to complete any of the tasks; instruction continued until proficiency in the task was gained.

Procedure

The study employed a repeated measures design. All students wrote two position papers, one on the environmental effects of "tire fires" and the other on the environmental effects of "oil spills." One paper was written using word processing and the other by hand. To eliminate any potentially confounding order and topic effects in the experiment, the four classes of students were counterbalanced across two dimensions: (1) by topic written about (all papers written using computers), and (2) by the medium for the first composition (computer or paper and pencil) regardless of topic. Reference material in the form of newspaper and magazine articles describing the recent Exxon Valdez oil spill and a major fire at a nearby tire dump was made available to all students. Every class was told that their tire fire papers would be sent to the Ministry of the Environment and their oil spill essays to the president of the oil company. It was felt that these provisions would give the students a more concrete and meaningful sense of audience for their writing and would foster a greater sense of purpose in their work, two elements considered critical to an effective writing curriculum.

All of the writing tasks were integrated into the normally-scheduled communication arts classes. One 90 minute period was allotted for drafting, and another 90 minutes was given for writing the final version. These amounts of time were typical of what the teachers would set aside for assignments of this nature. The teachers followed a specific set of instructions for introducing those assignments that were identical for all classes. At the end of the first 90 minute period, draft papers were collected (if handwritten) or printed (if computer-written) and all handwritten drafts photocopied so that all originals could be returned to students for work in the next writing session. In the second session, which occurred within three school days of the first, students were asked to revise their work and told that they had 90 minutes to complete their papers. The teachers again followed instructions provided by the researchers for beginning this session. Students were allowed to discuss their work with their writing partners if they wished but were not permitted to consult with their communication arts teacher about their essays. They were allowed to use their spellcheckers when working on the computer and dictionaries when writing with a paper and pencil. Final papers were collected at the end of the period. The entire procedure was then repeated for each class a second time, using the remaining topic and writing condition (on- or off-computer). Thus for each subject (excepting absences) there were four papers collected by the end of the study; a draft and final revision prepared using word processing and a draft and final revision on another topic written by hand.

The senior researcher had observed all classes at least four times before the study began and found no apparent differences between the typical patterns of social interaction of children during the study and their typical patterns during their regular writing classes. All children consulted with their writing partners during the study, although computer writing classes were typically more fluid and talkative than paper and pencil writing classes. Students would often comment on their partner's writing at the adjacent computer as their writing took shape. Students would also commonly stop and look at another classmate's writing on the screen and make brief comments as they walked to and from the two printers in the room.

Measures

Student handwritten work was transcribed on a computer and all work was printed out in the same style so that a blind 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 Table 1.

Table 1

Scale for Evaluating Expository Writing

Subscale	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.
Mechanics	The extent to which errors interfere with the writer's effectiveness in communicating.

The raters were trained by the investigators using procedures similar to those described by 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 using 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 rating process and assist the raters in maintaining rating consistency. All papers were scored by both raters. The interrater correlation across all scales was .86, indicating satisfactory reliability. For each paper, the ratings given by both raters for each of the four scales were averaged in order to set the paper's 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 ran unobtrusively in the background of the word processor) and taped on a disk an "electronic video" that could be played back to view the creation of the piece of writing from start to finish at any desired speed (ScreenRecorder, 1988). These "video tape" segments were coded into process categories and subject to quantitative and qualitative analyses. The nature of these analyses are discussed in the *Results* section.

Results

Product Analysis

The final scores on the four dimensions of writing were analyzed using a doubly multivariate repeated measures MANOVA design. Complete data sets for 68 students were available, the attrition being due to absences. Computer-written papers were rated 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 2).

The lengths of the computer-written and handwritten final papers were compared using a paired t-test. The mean lengths in words for the

Table 2

On- and Off-Computer Final Scores on the
Scale for Evaluating Expository Writing

	On computer		Off computer		
Scale	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*

Note: $n = 68$.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

two paper types (M(on computer) = 199.32, M(off computer) = 199.20) were not significantly different ($t(104) = .01$, $p = .994$), but the word-processed compositions showed much greater variance in their length (SD(on computer) = 155.32, SD(off computer) = 100.12).

Given the possible influences of spelling correctness on holistic ratings of student writing, as demonstrated by Froese (1989), we wondered if better spelling alone could account for the higher ratings assigned word-processed texts. In order to determine if differences in spelling accuracy on- and off-computer might bias the paper ratings in the present study, a random sample of 100 papers, half of which had been written using word processing, were assessed to determine the total number of spelling errors they contained. No significant differences across the two writing media were found in mean spelling errors per paper (M (off computer) = 7.06, M (on computer) = 7.76; $t(93) = -.72$, $p > .05$).

ScreenRecorder Data Analysis

Although 40 students were monitored using the ScreenRecorder software, a complete data set was available on only 19 students. This sharp mortality rate was due to either student absences on one of the four data collection dates 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 increments or additions. These are discussed in the next section.

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 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 made layout features available, (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 may 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.

Frequency of Use and Amount of Text Involved for Coded Keyboard Actions

Table 3 summarizes the frequency of use of the four coded keyboard actions described above. The distinction of draft/final is maintained because this is the distinction under which students created the texts. Table 4 summarizes the amount of text involved for the coded keyboard actions.

Text Scanning

As illustrated in Tables 3 and 4, several trends emerge with respect to the students' use of computer tools in scanning text. First of all, students made use of cursor movements to scan text more often in the drafting session than in the final session. There was a slight shift away from cursor key use to using the mouse for scanning words or word clusters less than a t-unit in the final session.

Students also used page-up/page-down and home/endpoint keystrokes to move through their texts. Not surprisingly, the page-up function was used more frequently in the final session when the students' full text was less likely to fit into one screen. This phenomenon might also explain, in part, the shift away from micro-scanning features (such as cursor movements) in the final session. The page-down feature, however, was used with similar frequency in draft and final sessions.

Table 3

Frequency of Keyboard Actions

Keyboard Action	Draft			Final		
	Mean freq. of use	No. of non-users	Range of freq. of use	Mean freq. of use	No. of non-users	Range of freq. of use
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	3.00	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
Endpoint	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	—	19	—	0.16	16	0–1
File	0.84	9	0–3	2.00	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	1.00	5	0–4	0.74	7	0–2
Macros	—	19	—	—	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

Note: $n = 19$.

Over half of the students did not observably return their cursors to the beginning point of their texts in either the draft or final stages; however, this does not preclude a reading from the beginning point given the nature of the screen display. In contrast, students returned to the endpoints of their texts more often in the drafting session, indicating that students often left the endpoint of the text to go back and rework or scan it.

Students used a variety of keyboard features to scan text. They moved about the text quite frequently (making an overall average of 22.6 moves

Table 4

Amount of Text Involved per Keyboard Action

Keyboard Action	Letter			Word			T-unit			Spacing			Punctuation		
	Mean No. of Letters	Freq. of non-use	Range	Mean No. of Words	Freq. of non-use	Range	Mean No. of t-units	Freq. of non-use	Range	Mean No. of Spaces	Freq. of non-use	Range	Mean No. of Punct.	Freq. of non-use	Range
Draft Text															
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															
Back-spacing	1.34	0	.67–44	0.63	0	.3–4.2	0.07	14	0–21	0.01	16	0–.04	0.05	18	.04–29
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	0.16	14	0–.88	0.12	10	0–1
Text entry	1.78	0	.76–2.5	4.7	0	1.4–9.4	0.16	18	0–.48	—	—	—	—	—	—

Table 4, cont.

Amount of Text Involved per Keyboard Action

Keyboard Action	Letter: Mean No. of Letters	Letter: Freq. of non-use	Letter: Range	Word: Mean No. of Words	Word: Freq. of non-use	Word: Range	T-unit: Mean No. of t-units	T-unit: Freq. of non-use	T-unit: Range	Spacing: Mean No. of Spaces	Spacing: Freq. of non-use	Spacing: Range	Punctuation: Mean No. of Punct.	Punctuation: Freq. of non-use	Punctuation: Range
Final Text															
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															
Back-spacing	1.16	6	0–3.33	0.5	7	0–2	0.01	18	0–1	0.08	15	0–1	0.04	16	0–2.33
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	0.08	14	0–.67	0.13	15	0–.5
Text entry	1.99	12	0–3.67	4.5	12	0–7.06	0.01	13	0–.25	—	—	—	—	—	—

in the draft session and 15.7 in the final session). To some extent the type of move made seemed to relate to the amount of text written and the point at which the students were in the composition.

Use of Menu-Bar Options

During composition sessions on the computer, students did not make frequent use of the tools and options accessible via the menu-bar with the notable exception of the utilization of formatting commands during the draft session. Given the nature and function of the menu options in relation to composition, students' limited use of options (other than those for spellchecking and editing) seems sensible. Indeed spellchecking, which was undertaken by all students at least once, was used more frequently and by more students in the draft sessions. The greater use of spellchecking in the draft session may be related to the students' greater use of text formatting features (such as font style and size) during drafting. Both are indicative of writer concern with the visual presentation of text. Clearly, for most writers in the study, decisions about the visual presentation of their texts were made very early in the writing process.

Text Deletions

When making deletions from their texts, students preferred to backspace rather than use the block-delete feature. As illustrated in Table 3, they backspaced on average three times more often in the draft session. Most students seemed to be using the backspace delete keystrokes efficiently; they were deleting either letters or words with them as opposed to longer text segments (see Table 4). One notable exception was a student who deleted 21 t-units in the draft session by using the backspace delete keystroke.

Most students made little use of the block-delete feature. When block deletion was used, either t-units or words were deleted. While the low frequency of using block deletion for letter-deletion is a positive sign, the use of block deletion for single words is slightly less efficient than backspace deletion (depending upon the position of the cursor). The small amounts of text deleted using either mode suggests that editing was taking place on a micro-text level. It may be that the use of Screen-Recorder made visible a level of text revision (and ultimately, of composition) common to much writing but not captured by traditional product-oriented analyses.

Text Additions

Text additions were of two types, those involving the insertion of text into the body of a piece of writing and those involving the addition of text at the end of the writing (text entry). Insertions are invariably of a revisionary nature, while text entry involves continuing a composition to the point of closure.

As with revision by deletion, students made greater use of text entry in the draft session. But unlike revision by deletion, text insertion was used, on average, more frequently in the final session. This might suggest that text insertion could involve a greater depth of revision, at least in terms of the length of text involved. However, in both the draft and final sessions text insertion rarely involved t-unit lengths of text. One point of note is that all but one student used text insertion. That student is the same one mentioned above who used backspace deletion only once to delete 21 t-units of text.

Additions to the end of text (text entry) dropped dramatically from the draft to final sessions. Eight of the 10 students who did not add to the text in this manner in the final session 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.) This pattern is at odds with that noted by Daiute (1986), who found that students writing on computer tended to make additions to the end of their texts rather than within their texts. In general, both the frequency and range of text entry revealed by the ScreenRecorder data highlights the fluidity and recursiveness of writing. For instance, if the data for text entry during the draft session are considered, students stopped writing, moved to some other point in the text, and came back to the end of the text to continue writing an average of 34 times (with some students doing so as little as 14 times and others as often as 58 times).

When the amount of text involved in text-entry is examined, it is consistent with the nature of the amount of text involved in other keyboard actions in that small increments of letters and words were added. Most students did not add text of one or more t-units. For these students, writing proceeded a few words at a time, iterated with frequent revisits to earlier sites in the text for perusal or micro-text editing in the form of word/letter additions or deletions before continuing on with the text.

Individual Student Profiles

If examined by coding category, the data gathered using ScreenRecorder reveal a continuum of use patterns across individuals as well as a preferential use of selected features for the sample group as a whole. The grouped data analysis by itself is incomplete, for it 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. The draft and final versions of their papers appear in the Appendix.

Cathy: A Relatively Effective and Efficient Computer User

In examining the coding categories for the draft session, Cathy's name is repeatedly found as either the most frequent user of a feature or among the most frequent users of a feature. Cathy used the block-delete feature appropriately in relation to the amount of text involved. For example, in one instance she block-deleted a total of six words and 11 t-units, and in another instance 7 t-units were block-deleted. 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 frequently, 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 mostly 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 might become more efficient and effective, in comparison to the other students in the draft session, she appeared to be a relatively efficient and effective user of the computer as a writing instrument. Her writing, as 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 made no use at all of 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 via the menu-bar, filing via the menu-bar, formatting via the menu-bar, spelling via the menu-bar, page down, and page up. She used forward cursor movement 7 times on small text increments, backward cursor movement 5 times on small text increments, and she moved to the end of her text 5 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 an average entry per keyboard action of 1.38 letters, 6.67 words, and 0.08 t-units. She tended to work in small text increments, a pattern similar to many others in the sample. Barbara's papers were rated "5" (the highest score) on all dimensions of the *Scale for Evaluating Expository Writing*. However, Barbara was unique in her under-use 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, e.g., 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 in the draft session ("1"s and "2"s on the assessment scales) and neared the group mean for the final session.

Despite his limited use of all of these features, Jay did use one feature more than any other student: the format feature of the menu-bar. He constantly returned to the format feature during the draft session, using 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

The Effects of Experience and of Specific Word-Processing Environments

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 rated significantly higher in quality on each of the four scales (overall competence, focus, support, and mechanics) of Quellmalz's (1982) *Scale for Evaluating Expository Writing.* In an earlier study, Daiute (1986) hypothesized that the higher ratings given to computer-written papers may be an artifact of their greater average length relative to handwritten compositions. This explanation can be rejected in the present instance, as no significant differences were found in paper length between media. Nor were any significant distinctions found between the two groups of papers with respect to the average number of spelling errors per paper, eliminating the possibility that the assignment of higher mean ratings to word-processed compositions was due wholly or in part to the fact that they contained fewer such errors. Even with the elimination of these two hypotheses, however, the reasons for the higher ratings of the computer-written work are not entirely clear. We suspect that the explanation for the observed differences has to do with students' extensive prior experience in keyboarding, their familiarity with and capability of using the GUI-based editing and text manipulation features of the Macintosh version of the Microsoft Works word processor used in the study, and their frequent use of this writing environment over several school terms.

The greater level of student experience and competence in using the word processor employed in the study differentiates this study from most other research on computers and writing that has been done using subjects of similar age. It is highly probable that grade eight students would need extensive practice in using a new writing technology that is vastly more complex than the familiar paper and pencil before they could expect to gain any significant benefit from its employ. The relative role of experience and competence-in-use in determining the effects of word processing on writing will only be understood through more study.

The study is also differentiated by its use of word-processing software with a graphical interface incorporating pulldown menus and mouse-controlled functions, features which made it easier for students of this age to take advantage of some of the functionality that word processing can offer in the writing process. While most of these features are also available in more traditional character-based and command-line driven word processors, the relatively greater cognitive effort required to make use of them may dissuade writers (especially younger ones) from doing so to any significant degree. Some support for this notion is offered by Haas

(1989) who found that the use of a word-processing environment similar to that employed in the present study resulted in writing of significantly higher quality than that produced using character-based text editors on traditional PCs. Further work will be necessary to determine if there is any interaction between the type of word processor used and writing quality, particularly with young children. It may be that for younger students no practical amount of experience using character-based systems will have an impact on compositional quality because the complex interfaces of these systems are beyond the capacity of most students to master and integrate effectively into their writing practices.

It is worth noting that the students' long-term acquisition of word processing skills may have contributed to the development of new writing styles or skills that have since diffused into their off-computer writing, possibly influencing the quality of handwritten composition. The present experiment makes no attempt to address this important issue. The data indicate only that word-processed texts are rated more highly regardless of the degree of diffusion that may have occurred.

What the ScreenRecorder Data Suggest About Writing Strategies

The ScreenRecorder data obtained from a sample of student writing provide some insight into the kinds of experimentation with language that the computer facilitates and give further clues as to why the computer-written work was judged to be of higher quality than handwritten work.

Students in our study used the computer as a writing tool in much the same way as the experienced and professional writers described by Lutz (1987). They made many changes "at lower linguistic levels," and "they moved in smaller chunks from one change to the next" (Lutz, p. 407). Some students engaged in much more revision 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. Spellchecking was also used more frequently in the draft than the final sessions. 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) students had not yet come to trust their ability to use the text moving feature; or (c) the blocking of the text had been inadvertent.

The use of formatting features was also more prominent during the draft session. A number of explanations seem plausible for this behavior. Because the Macintosh screen displays the text as it will be printed (unlike character-based systems 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. Alternately, 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 actively composing, and their actions would be observably similar to peers who were composing. It is possible that some students engaged in this behavior to delay the writing task. Or, certain fonts may be thought 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. The refinement of the graphic display (if interpreted as non-semantic in nature) has been an element which writing experts studying handwritten production (e.g., Graves, 1983) suggest students leave until the final editing or, as Sullivan (1991) suggests, to external editors. The establishment of a "format" by the young writers in the present study gives some support to Sullivan's assertion that control over word *publishing* is one of the ways in which electronic writing changes the writing process.

Fewer students chose to insert new text into previously written material during the final session than during 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, spellchecking, and formatting, they suggest that the labels "draft" and "final" are misleading, because writing on computers seems to foster an ongoing and interactive 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 categorized more easily as "draft" and "final." This gives some support to the recursive view of writing advocated by Emig and others as discussed in Faigley, Cherry, Jolliffe, and Shinner (1985).

Despite students' ability to use the block and the cut-and-paste features of Microsoft Works for editing (as indicated by the editing pretest), few chose to make use of them in either session when writing with a computer. This was not too surprising as the teachers, during their regular instruction, did not emphasize reasons why a writer might want to carry out block operations on text. Additionally, the amount of text involved in the action may have influenced the keyboard action selected. Most text deletions were quite short; many students may have decided (appropriately enough) that short deletions were more efficiently carried out using the delete key. When the present findings about the lack of macrostructural editing, the movement around the text, and the revision in small text increments are combined with similar evidence from Lutz's study of experienced and professional writers, the substantive issue becomes whether the computer makes visible the processes hidden in handwritten composition or whether the computer results in different writing strategies regardless of the age of the writer. Since adults in the Lutz study talk of the "mushier" state of their writing and their tendency to "evolve a text" (p. 415), it may be inappropriate to use macrostructural revision as a criterion for differentiating between on- and off-computer writing. Flower, Hayes, Carey, Schriver, and Stratman (1986) have alluded to "different [writing] strategies adapted to the technology of word processing" (p. 18). The evidence from the present study supports this contention and, in doing so, raises a flag for researchers investigating the impact of computers on writing. To avoid being blinded by assumptions carried from analysis of handwritten composition, researchers must remain alert to these assumptions when evaluating computer-written text.

Conclusions

Analysis of the ScreenRecorder data indicated that students vary in their approach to composing using word processing. As Cochran-Smith and others have suggested (1991), students appear to bring their own personal style of working to the word-processing environment. Word processors appear to accommodate to whatever level of editing the user wishes to employ. For some writers, like Barbara, the computer may not make too much difference. For others, like Jay, the computer's capabilities may actually take away from the writing event, given an interfering interest in graphics. Yet writers like Cathy are able to use the capabilities of the computer to their advantage, resulting in the creation of a moderately successful piece of writing.

Because of the writing options the computer provides, it may be that different descriptions 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.

One of several aspects of the ScreenRecorder data which have yet to be fully explored is the students' use of the spelling checker. It is possible that the pattern 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, 1991). In addition, a detailed semantic analysis of the texts written on and off the computer should provide further insights into computer writing. It may be that small, seemingly surface-level-only revisions have a differential impact on computer-produced writing because of their frequent occurrence, giving rise to a cumulative alteration of textual cohesion and coherence. Studies of both of these questions are currently underway. Also, we have begun to develop and apply coding systems to the ScreenRecorder data. Collectively, this work should lead to a more complete knowledge of computer writing as well as to a broader understanding of the relationship 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* (pp. 123–149). Norwood, NJ: Ablex Publishing.

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 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.
Evans, B. (1986, April). *The integration of word processing and computer instruction with fifth and sixth graders.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.
Engberg, P., (1983). I'll write, just lead me to my computer. *Classroom Computer Learning, 4*(2), 68–69.
Faigley, L., Cherry, R. D., Jolliffe, D. A., & Shinner, A. M. (1985). *Assessing writers' knowledge and processes of composing.* Norwood, NJ: Ablex.
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. *Dissertation Abstracts International, 46,* 3636A. (University Microfilms No. 86-02, 959).
Flower, L. Hayes, J. P., Carey, L., Schriver, K., & Stratman, J. (1986). Detection, diagnosis, and the strategies of revision. *College Composition and Communication, 37,* 16–55.
Froese, V. (1989, April). *Aspects of holistic scoring validity.* Paper presented at the annual meeting of the National Testing Network on Writing Assessment (7th), Montreal. (ERIC Document Reproduction Service No. ED 305 647)
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.
Hawisher, G. (1986). Studies in word processing. *Computers and Composition, 4*(1), 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 G. E. Hawisher & C. L. Selfe (Eds.), *Critical perspectives on computers and composition instruction* (pp. 44–69). New York: Teachers College Press.
Hill, C. A., Wallace, D. L., & Haas, C. (1991). Revising on-line: Computer technologies and the revising process. *Computers and Composition, 9*(1), 83–109.
Hooper, S. C. (1987). *Using word processing 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)
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. *Dissertation Abstracts International, 49,* 1368A. (University Microfilms No. 88-16, 133).

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, l27*(1), 13–19.
Lutz, J. A. (1987). A study of professional and experienced writers revising and editing at the computer and with pen and paper. *Research in 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. *Dissertation Abstracts International, 48*, 635A.
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, P. D., Murphy, S., & Wideman, H. H. (1991). On and off computer writing of eighth grade students experienced in word processing. *Computers in the Schools, 8*(4), 67–87.
Pearson, H., & Wilkinson, A. (1986). The use of the word processor in assisting children's writing development. *Educational Review, 38*, 169–187.
Quellmalz, E. (1982). *Scale for evaluating expository writing*. (ERIC Document Reproduction Service No. ED 236 670)
Rodrigues, D. (1985). Computers and basic writers. *College Composition and Communication, 36*, 336–339.
ScreenRecorder. (1988). [Computer program]. Berkeley, CA: Farallon Computing.
Sommers, N. (1980). Revision strategies of student writers and experienced adult writers. *College Composition and Communication, 31*, 378–388.
Sullivan, P. (1991). Taking control of the page: Electronic writing and word publishing. In G. E. Hawisher & C. L Selfe, (Eds.), *Evolving perspectives on computers and composition studies: Questions for the 1990s* (pp. 43–64). Urbana, IL: National Council of Teachers of English.
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.
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.

Appendix

Cathy

Computer-Written Draft Version

THE TIRE FIRE

I think that the tire fire is a real big problem. The fire has been burning for 16 days they say that a arsenest stared the fire. They think it should be out by the end of march. There is 14,000,000 tires burning. And they had to evacuate 600 people because the tires are giving off oil and toxic fumes. The tire fire started on febuary 12 at one o-clock in the morning. The toxic fumes are causing water pollution and air pollution. There is going to be alot of damage to their enviroment and to their water supplies. The tire fire is in Hagersville. All the fumes is going damage their crops. I think is is wrong because it could effect the whole town and their enviroment. People who want to and sell their house in Hagersville can't because who would want a house with contaminated water and land. There have dumped 87,990 gallons on the tire fire so far. I think that the tire king should be put in jail for havine so may tires. I think that they should still keep on using water and chemicals. I don't think that they should try the product that the scientist said could put out a fire of any size because they don't know if its true or not true and it might make the fire bigger.

Computer-Written Final Version

THE TIRE FIRE

I think that the tire fire is a real big problem. The fire has been burning for 16 days they say that an arsonist started the fire. They think it should be out by the end of march there is 14,000,000 tires burning. And they had to evacuate 600 people because the tires are giving off oil and toxic fumes. The tire fire started on February 12 at one o-clock in the morning. The toxic fumes are causing water pollution and air pollution. There is going to be a lot of damage to their environment and to their water supplies. The tire fire is in Hagersville. All the fumes is going damage their crops.

I think it is wrong because it could effect the whole town and their environment. People who want to and sell their house in Hagersville can't because who would want a house with contaminated water and land. There have dumped 87,990 gallons on the tire fire so far.

I think that the tire king should be put in jail for having so many tires. I think they should still keep on using water and chemicals. I don't think that they should try the product that the scientist said could put out a fire of any size because they don't know if its true or not true and it might make the fire bigger.

Barbara

Computer-Written Draft Version

Oil and the Effects on Our Environment

Exxon Valdez, a supertanker carrying 53 million gallons of crude oil strayed a mile and a half off its course, where it dragged over sharp rocks that ripped large holes in its hull. March 24 1989 the accident happend, March 25 1989 the clean up of 11 million gallons of crude oil from the Exxon Valdez began. 1000 miles of coastline was covered in oily scum. Thousands of birds and animals covered in oil were eating oil soaked vegatation, most of them died before they could be helped.

The problem it this has not been the only spill. Whenever a spill like this happens wildlife and vegatation dies, our economy also suffers. Maybe the design of the ships is wrong or the fines might not be heavy enough, what ever the problem is it has to be found before it happens again.

The government needs to be more strict with fines, they also need to stress that the penalties for bringing alcohol onboard a seagoing ship will be severe. The companies transporting the oil should have an emergancy team of ships with the tanker on all voyages in case of an accident. Smaller loads of oil on the ships would keep any future spills from being as devastating.

There is alot that can be done to prevent these spills, I have just listed several ideas to do this. If something is done than maybe we can keep our environment and the wildlife in it somewhat safer.

Computer-Written Final Version

Oil and the Effects on Our Environment

Exxon Valdez, a supertanker carrying 53 million gallons of crude oil strayed a mile and a half off its course, where it dragged over sharp rocks that ripped large holes in its hull. March 24 1989 the accident happened, March 25 1989 the clean up of 11 million gallons of crude oil from the Exxon Valdez began. 1000 miles of coastline was covered in oily scum. Thousands of birds and animals covered in oil were eating oil soaked vegetation, most of them died before they could be helped.

The problem it this has not been the only spill. Whenever a spill like this happens wildlife and vegetation dies, our economy also suffers. Maybe the design of the ships is wrong or the fines might not be heavy enough, what ever the problem is it has to be found before it happens again.

The government needs to be more strict with fines, they also need to stress that the penalties for bringing alcohol on board a seagoing ship will be severe. The companies transporting the oil should have an emergency team of ships with the tanker on all voyages in case of an accident. Smaller loads of oil on the ships would keep any future spills from being as devastating.

There is alot that can be done to prevent these spills, I have just listed several ideas to do this. If something is done than maybe we can keep our environment and the wildlife in it somewhat safer.

Jay

Computer-Written Draft Version

BLAZE IN HAGERSVILLE

Approx 2 weeks ago the 14 million tie were set on fire to leave a national disaster. Leaving 600 homeles and the owner unwanted. The poeple that have been evacuated from there homes. The Land owners should try to sell there land because the tire fire could go on for months or even a year. I'm woundering where the people will get the mney.

Computer-Written Final Version

BLAZE IN HAGERSVILLE

Approx. 2 weeks ago the 14 million tire were set on fire to leave a national disaster. Leaving 600 homeless and the owner unwanted. The people that have been evacuated from there homes. The land owners should try to sell there land because the tire fire could go on for months or even a year. I'm wondering where the tires will go in the next five years? Where will Ed Straza be and what will be his penalty? I think the worst is yet to come. The oil that spilled will be very close to the water table and in a lot of wells and the drinking water will be contaminated. Where will the people will get the money to buy a new house if they have to move because of the living conditions? I want to know what the government is doing? What are we going to do with all that oil? The land is ruined so they should turn the land into a dump site! Put a big steel basin around and under it. The tires should be broken down and used for something like swings at a park or the boundries and a race way or a go cart race way. The fire wasn't the problem the national disaster is yet to come.