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Technology in the Classroom:

Do Computers Change the Way We Write?

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Enthusiasm for using computers to write and to teach writing has been strong among those of us who have a special interest in both computers and writing. We believe--usually based on our own experiences as writers--that the computer lessens the tediousness of writing, that computers free us from the mundane aspects of writing, that computers allow writers to focus on content and meaning, and that computers encourage revision. We assume that the computer's strengths--speed and vast memory capacity--somehow help the writer, and that the result is more and better writing.

Unfortunately, there is little empirical evidence to support our assumptions. In fact, what little there is seems to contradict them: for instance, John Gould in his important 1980 study, found that expert writers using text editors required 50% more time to compose on text editors than on hard copy. But this extra time did not lead to "better" writing; there was little difference in quality between letters produced on text-editors and those produced on paper. Although computers may aid writers in some ways, these effects did not show up in Gould's study as longer or better writing.

Of course, since 1980 technological advances have improved the usability, power, and attractiveness of text-editors and computer displays.. Possibly these design advances have made writing on the computer more efficient and Gould's troubling results are simply

outdated.

The purpose of this study was two-fold: first, it attempts to partially replicate Gould's experiment, using more advanced machines and editors. Second, it tests several hypotheses about writing with the computer. Specifically, that computers help writers produce more text, produce text faster, and that computers help writers write *better.*

These questions are important for educators to ask--we need to know how different hardware and software features affect writers and writing. Only then can we make informed choices about when and how to utilize computers in the classroom--and what *kind* of computers to use.

Subjects: The fifteen subjects were experienced writers--faculty, administrators and system designers from Carnegie-Mellon University. The 11 men and four women ranged in ages from 23 to 42. All of the participants had had at least several years of computer experience, and all worked daily or almost daily on the machines on which they were tested.

Tasks: Subjects wrote persuasive letters in four conditions. Two were to a known audience and two were to an unknown audience. The participants produced the letters in two sessions--two letters the first day, and two letters the second day. Topic and order were counterbalanced across conditions.

Conditions: The participants wrote letters in a hard copy condition and in three computer conditions. In two of the computer conditions writers wrote using "Andrew," an advanced computing system and related software being developed at the Information Technology Center as a joint venture of Carnegie-Mellon University and IBM (Morris, et al, 1986).

The advanced workstation has a large, bit-mapped, high-resolution display, and a mouse. The text-editor was developed at the ITC and based on EMACS. Placement of the cursor for editing the text is done by pointing the mouse and clicking the mouse button. Writers move through the document by pointing the mouse and clicking in a scroll bar region. For cutting text, writers used either a delete key or a menu option; pasting was also done via a menu. In one condition the window used for writing was 9 1/2 inches wide and 10 1/2 inches long. The other advanced workstation condition differed only in the size of the screen: it was 9 1/2 inches wide and 6 1/2 inches long, the size of a standard pc or terminal display.

In the other computer condition, writers used an IBM-PC and the text-

editor MINCE, also based on EMACS. The pc had a 9 1/2 inch by 6 1/2 inch screen and a CRT display. Moving the cursor, moving through the document, and editing are done with control-keys. In the pen-and-paper condition writers used 8 1/2 by 11 inch ruled paper and their choice of a felt-tip or ball-point pen. When writing in the computer conditions, writers were not allowed to use pen and paper notes, not to get a printout of their texts.

The salient differences between the computers are summarized in the table below.

	workstation	pc
Machine		
speed	16 kilo-baud	9600 baud
resolution	bit-mapped black on gray	CRT green on black
screen size	9 1/2 by 10 1/2 50 lines by 90 characters	9 1/2 by 6 1/2 24 lines by 88 characters
Editor (Note: all computer conditions used display editors.)		
text advancement method	scroll bar and mouse	control-keys
cursor movement	mouse/pointer	control-keys
editing--deleting, cut/pst	mouse/menu; delete key	control-keys

Analyses

I looked at three quantitative measures: time to compose the letter, total words produced, and words produced per minute. Because there was no significant difference in any measure between the workstation large and small conditions, these data were collapsed into a single workstation condition and scores were normalized for topic and order effect.

Time to compose was longest in the advanced workstation condition, and shortest in the hard copy condition. These differences were

significant at the .02 level by analysis of variance. Neuman-Keuls analysis shows this variance accounted for by a significant ($<.05$) difference between the workstation and paper conditions.

Time

Cond. 1, workstation	17.40 minutes
Cond. 2, pc	15.12 minutes
Cond. 3, pen-and-paper	13.43 minutes

The second measure--number of words produced--also showed a significant difference, with the highest mean number of words in the advanced workstation condition, and the smallest mean number of words in the hard copy condition. These differences are significant at the $<.01$ level by analysis of variance. Neuman-Keuls shows the variance to be accounted for by a significant difference between conditions 1 and 3. Condition 2 was not significantly different from either of the other conditions.

Total Words

Cond. 1, workstation	352.79 words
Cond. 2, pc	291.62 words
Cond. 3, pen-and-paper	264.05 words

The words-per-minute measure shows no significant difference between conditions--workstation 20.17 wpm; pc, 21.00 wpm; pen and paper, 20.94 wpm.

So in terms of quantity--both time on task and total words--the advanced computer seems to outperform pen and paper although the pc, ofr standard computer condition does not. But of course quantity is only half the story.

So, I also collected two measures of writing quality: Independent readers (English teachers with at least five years experience teaching writing) rated each subject's letters using a forced quartile split. The letters received scores for *content*--quality of ideas--and for *mechanics*--sentence- and word level-correctness. Agreement between two raters was 80%. When raters scores were more than one quartile different, a third reader read and rated the letters. Again, because there were no discernable difference between the two workstation conditions, the data was collapsed into a single workstation condition. With possible scores ranging from 2 (low) to 8 (high), mean scores for each condition were:

Content

Cond. 1, workstation	5.96
Cond. 2, pc	4.0
Cond. 3, pen-and-paper	5.13

Mechanics

Cond. 1, workstation	5.23
Cond. 2, pc	4.26
Cond. 3, pen-and-paper	5.67

The content measure differences are significant at the .02 level by analysis of variance. Neuman Keuls analysis shows that the texts produced in the pc condition were significantly poorer ($<.05$) than those produced in the advanced workstation condition. The differences between the pc condition and the hard copy condition were just short of significant. Although the differences in mechanics scores are not significant, the mean scores for the PC Condition are again the lowest.

In addition, the difference in *total quality* scores was significant at the .02 level by analysis of variance. Mean total scores--sum of content and mechanics scores--were:

Total

Cond. 1, workstation	11.20
Cond. 2, pc	8.26
Cond. 3, pen-and-paper	10.89

Neuman Keuls analysis shows again, that the pc condition was significantly different ($<.05$) from the advanced workstation condition and from the hard copy condition.

To summarize, writers on the whole produced significantly *more* text with the advanced workstation than they did with pen and paper, AND they produced signifcantly *better* texts with pen and paper and the advanced workstation than they did with a standard computer. Unfortunately, I can't say much yet about WHY these differences occurred, beyond noting that screen size doesn't seem to account for the difference. The improvement in performance of subjects in this study over Gould's probably has to do with the differences between line editors and screen editors. Beyond that, these results may be due to machine speed, resolution, method of moving through the text, method of editing--ie, mouse vs. ctrl keys.

Conclusion

Let's return to the questions with which this paper began: we noted two different sets of claims--one that computers will help people write more and better, and the other--supported by Gould's early work--that machines do not lead to more or better writing. These seemingly contradictory claims can be reconciled if we elaborate them: *some* computers can help people write more and better, but *some* machines may also make them write more poorly.

Advances in machine design are encouraging--the poorer performance Gould found with computers seems to have turned, with more advanced machines, to a slight advantage for computers. However, this encouraging finding should be qualified in two important ways: the positive results come from a very advanced--and needless to say, expensive--machine, the kind of computer that most of us don't have access to. They are not even widely available at CMU, or "Computer U," as its sometimes called. We cannot assume--and indeed these results prohibit us from doing so--that the kind of computer typically used in education today will aid writers in the way that this workstation did in this study. (Lest I sound to negative, I acknowledge that many parts of the writing process and many kinds of writing may be greatly aided by the computer. In addition, many excellent word-processing programs and CAI programs may help writers and help teachers teach writing.) What I am advocating is restraint in assuming that because of the computers strengths, it be adopted whole and with little critical evaluation by teachers of writing and writers.

Second, the writers in this study are experienced, expert writers and computer users. All wrote regularly on the job; most had been using computers for at least 10 years; many had advanced degrees; and all were significantly older than most of our students. We should not be too hasty and extrapolate these findings to students--usually novice computer users, and often poor writers as well. Overall, the conclusion of these studies advocates CARE--there remains much to be done to determine when, where, with whom, and how computers can best aid writing.

Our own research will pursue examination of the processes of experienced computer users and writers, to determine first, if there are process differences which led to the quality differences demonstrated here. Second, these results, together with earlier reports of computer writers' conscious adaptation of their writing process into a "system" for computer writing, (see Haas and Hayes, 1986), lead to the hypothesis that these experienced computer writers have "learned" to write well on the machine. We plan to continue to explore just how computer writers utilize the strengths and adapt to the constraints of

the computer when writing.

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ANOVA for Time to Compose

source	df	mean squares	F	prob.
Subjects	14	56.049		NS
Conditions	2	59.411	4.35	<.02
Subjects X Conditions	28	13.653		

Newman-Keuls Tests of Significance
for Time to Compose

	Advanced Workstation	PC	Pen and Paper
Advanced Workstation	———	2.40	4.178*
PC		———	1.18
Pen and Paper			———

*$p < .05$

ANOVA for Total Words Produced

source	df	mean square	F	prob.
Subjects	14	19292.49		NS
Conditions	2	30944.97	4.74	<.01
Subject X Condition	28	6528.48		

Newman-Keuls Tests of Significance
for Number of Words Produced

	Advanced Workstation	PC	Pen and Paper
Advanced Workstation	_____	2.93	4.25*
PC		_____	1.32
Pen and Paper			_____

*p<.05

ANOVA for Content Quality

source	df	mean square	F	prob.
Subjects	14	.69286		NS
Conditions	2	14.61667	4.08	<.02
Subjects X Conditions	28	3.58095		

Newman-Keuls Tests of Significance
for Content Quality

	Advanced Workstation	Pen and Paper	PC
Advanced Workstation	_____	1.72	4.03*
Pen and Paper		_____	2.31
PC			_____

*p<.05

ANOVA for Total Quality

source	df	mean square	F	prob.
Subjects	14	3.3317		NS
Conditions	2	37.9556	4.28	<.02
Subject X Condition	28	8.8603		

Newman-Keuls Tests of Significance
for Total Quality

	Advanced Workstation	Pen and Paper	PC
Advanced Workstation	_____	.52	3.828*
Pen and Paper		_____	3.307**
PC			_____

*p<.05
**p < .10